Reproduction in organisms

Introduction

Period from birth to natural death is called lifesplan but single celled organisms are immortal and reproduction enables continuity of species

The organisms habitat, internal physiology are responsible for how it reproduces & it is mainly of two types based on no. Of parents → ASEXUAL, SEXUAL

Term clone is used to describe the morphological and genetical similar individual

Common in single celled organisms (cell div. = reproduction)

Asexual Reproduction

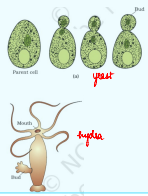
Single parent is involved

Fragmentation
In hydra

Gemmule formation
In sponges

AIPMT2015

Budding
In yeast and hydra



Binary fission
In single celled like amoeba and paramecium

Spore formation
In fungi, simple plants/algae like zoospores in chlamydomonas and conidia in penicillium

Vegetative propagation
(Term used for plants) and example of vegetative propagules are

The origin of plantlets takes place from nodes. Adventitious buds in bryophyllum is an example.

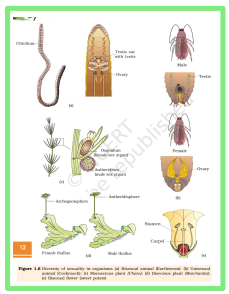
Algae and fungi starts doing sexual reproduction before adverse conditions

- **Runner** Grass
- **Rhizome** Ginger — AIPMT 2015
- **Buds** Leaf Buds of Bryophyllum — AIPMT 2011
- **Tuber** Potato
- **Offset** Pistia, Ecchornia (Water hyacinth)
- **Bulb** Onion, Garlic
- **Bulbil** Agave — AIPMT 2011
- **Sucker** Banana
- **Eyes** Potato — AIPMT 2011

Water hyacinth/terror of Bengal caused havoc by choking water bodies and it grows in standing water

Encystation in amoeba

Under unfavourable condition amoeba withdraws pseudopodia & secretes 3 layered covering(cyst) and process is called encystation & when the condition is favourable the encysted amoeba multiplies by multiple fission & cyst burst giving rise to several amoeba which is known as sporulation.



Reference diagram for text given on next page

Sexual reproduction

2 parents are involved

It involves formation of gamete either by same individual or different

offsprings are not identical (NEET 2016)

Females of placental mammals exhibit cyclic changes in reproductive phase which in non primates(cow,sheep,rat) is called oestrous cycle & in primates(monkey,human) is called menstrual cycle

Birds in nature lay eggs seasonally but poultry lays eggs throughout the year which is not reproduction

Slower than asexual

Seasonal breeders- Experience cyclic changes in particular season

Continuous breeders- Reproductively active throughout the reproductive phase

Events in sexual reproduction

- Pre fertilisation
- fertilisation
- Post fertilisation

All organism go under juvenile/growth/vegetative and reproductive phase which can be understood in annual or biennial plants but not easy to understand in perineal

Reproductive phase in plants is marked by flowering

Bamboo species flower once in 50-100 years,produce lots of fruits and die (NEET 2018)

Strobilanthus kunthiana (Neelakurunji) flowers once in 12 years & lastly flowered in sept-oct 2006 in south & its blue strips attracts tourists

Body experience concomitant changes(slowing down of metabolism) in last phase of life span

Hormones are responsible for three phases of life

Pre-fertilisation events

1) Gametogenesis(gamete formation)- in algae and male and female gamete look similar called homogametes(isogametes) but in majority heterogametes are found.

For fungi and plants homothallic/monoecious stands for bisexual and heterothallic/dioecious for unisexual

=> unisexual male flower is known as staminate and unisexual female flower as pistillate

Monoecious plants-cucurbits,coconut

Dioecious plants-papaya,date palm

Bisexual animal/hermaphrodite-earthworm,sponge,tapeworm,leech

Cell division during gametogenesis-

Gametes are always haploid (may arise by mitosis in haploid parent like monera,fungi,algae,bryophytes or meiosis in diploid parent like pterodophyte,gymno,angio,humans

In diploid organism special cell called meiocyte(gamete mother cell) undergo meiosis

2) Gamete transfer-

In some algae & fungi both gametes are motile. In algae,bryophyte,pteridophyte water is medium thr' which gametes are transferred and in bisexual plant(peas) it is easier but in unisexual it requires pollination

Fertilisation/syngamy

Parthenogenesis-female gamete undergoes development & form new organism without fertilisation. Eg- rotifers,honeybee,lizards,birds(turkey)

External fertilisation- Eg- algae,fishes,amphibians,bony fishes,frog. It requires great synchrony b/w sexes & more amt. of gametes but is risky with predators.

Internal fertilisation- Eg- fungi,reptiles,birds,mammals,bryo.,pteridо.,gymno.,angio.

Generally in it male gamete is motile & female is non motile but in seed plants non motile male gamete is transferred thr' pollen tube

Post fertilisation events

1) The zygote-its development depends on type of life cycle the organism has and environment it is exposed to.

In alga & fungi, zygote develops a thick wall that is resistant to desiccation & damage thus undergoes period of rest before germination

In organisms with haplontic life cycle,zygote divides by meiosis to form haploid spores that grows into haploid individual. Zygote is vital link that ensures the continuity of species.

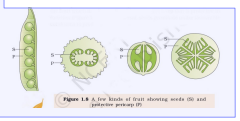
2) Embryogenesis-development of embryo from zygote during which it undergoes division(mitosis) & differentiation.

Oviparous=> development of zygote out of body and egg may be fertilised or unfertilised.

Viviparous=> have more chances of survival of baby(offspring)

In flowering plants zygote is formed inside ovule & after fertilisation all shed of only pistil remains attached to plant.

ZYGOTE ⟶ EMBRYO, OVULE ⟶ SEED, OVARY ⟶ FRUIT which develops a thick wall called pericarp that is protective in function



The lifespan of given species

The life span of the species is listed below.

- Dog life span – 20 to 30 years
- Elephant life span – 60 to 90 years
- Bana tree life span – 25 years
- Horse life span – 20 to 25 years
- Banyan tree – 200 to 500 years
- Rosebush life span – 5 to 7 years
- Fruit fly life span – 30 days
- Rice plant life span – 3 to 4 months
- Cow life span – 20 to 25 years

Sexual reproduction in flowering plants

Flower- reproductive unit meant for sexual reproduction.

Prefertilisation : structure & events

Hormonal, structural changes occur lead to differentiation & development of floral primordium, inflorescence are formed bearing floral buds.

(I) stamen, microsporangium, pollen grain

Stamen = anther + filament
The former/proximal end of filament is attached to thalamus or petal of flower.
Angiospermic anther is bilobed & each lobe having 2 theca (dithecous) often a longitudinal groove runs lengthwise separating theca. The anther is a foursided (tetragonal) structure consisting 4 microsporangia which further develop into pollen sac, packed with pollen grain & extend longitudinally all thr' the length.

NEET 2016

STRUCTURE OF MICROSPORANGIA
Appears circular in outline surrounded by 4 wall layers- epidermis, endothecium, middle layers & tapetum. The first 3 protects & helps in dehiscence of anther to release pollen & tapetum on being dense cytoplasm & binucleated nourishes pollen. In young anther sporogenous tissue (homogenous cells) occupies centre of each microsporangium. NEET 2013

MICROSPOROGENESIS
Sporogenous cell perform meiosis to form microspore tetrads. Formation of microspore from pollen mother cell (PMC) is microsporogenesis. The microspores arrange in clustre of 4 cells & afterwards microspore dissociate to develop pollen grain. (NEET 2016)

POLLEN GRAIN
They represent the male gametophyte & are of 25-50 um in diameter. Have 2 layered wall- 1st exine -> made of sporopollenin (resistant organic material upto high temp., acid, alkali & no enzymes can degrade it). It has prominent apertures (germpore where sporopollenin is absent) & cause of sporopollenin they are preserved as fossils. 2nd Intine -> thin, continuous, made of cellulose & pectin.
Cytoplasm of pollen is surrounded by plasma membrane. Mature pollen contains 2 cells vegetative & generative cell.
Vegetative is bigger, abundant food reserve, large irregular nucleus.
Generative is small,floats in cytoplasm of vegetative cell, spindle shaped, dense cytoplasm nucleus.

NEET 2013

60% angiosperms shed at 2 celled stage & 40% at 3 celled stage i.e. generative cell divide to form 2 male gamates before shedding.
Pollen grain may cause allergy & bronchial afflictions leading to asthama, bronchitis, etc. eg- parthenium (by imorted wheat) causes pollen allergy. Pollen are rich in nutrient & taken as food supplements as tablet/syrup. Which increase performance of athletes/race horse. Pollen of rice, wheat have viability of 30 min. But pollen of rosaceae, leguminoseae, solanaceae are viable for months. Pollen can be stored for years in liq. N2 (-196°C) and can be used as pollen bank in crop breeding programs.

AIPMT 2014
NEET 2018

(II) pistil, megasporangium (ovule) & embryo sac

Gynoecium may be monocarpellary (single pistil), multicarpellary which can be fused (syncarpous) or free (apocarpous). Inside the ovary there is ovarian cavity (locule) in which placenta is located.
Megasporangium/ ovule arise from placenta.
Uniovular- wheat, padddy, mango
Multiovular- papaya, watermelon, orchids.

MEGASPORANGIUM/ OVULE
Attached to placenta by a stalk (funicle) & its body fuses with funicle in region called hilum (junction b/w ovules & funicle) ovule have 1 or 2 protective envelope (integuments) which enclose nucellus except at tip (small opening called micropyle).
Opposite of micropyle is the chalaza end (basal part of ovule).
Integuments enclose mass of cells, the nucellas which have abundant reserve food material.
Embryo sac/female gametophyte is present in nucellus. & each ovule have 1 embryo sac formed from megaspore.

MEGASPOROGENESIS
Formation of megaspores from megaspore mother cell (MMC). Ovules differentiate a single MMC in micropylar region of nucellus.
MMC is a large cell with dense cytoplasm, prominent nucleus & it undergoes meiosis & forms 4 megaspores.

FEMALE GAMETOPHYTE
One of the megaspores is only functional & rest 3 degenerates. The one develops female gametophyte (embryosac). This is called as monosporic development.
Formation of embryo sac- nucleus of functional megaspore divide mitotically & the 2 nuclei shift to poles & again divide to form 8 nuclei stage of embryo sac. (These nuclear division are not followed immediately by cell wall formation). The six of 8 nuclei are surrounded by cell wall & the polar nuclei is situated below egg apparatus in large central cell.

Micropylar end (egg apparatus)- 2 synergids + 1 egg cell. Synergids have cellular. Thickenings at micropylar tip called filiform apparatus which guide pollen tube into synergid.
Chalazal end- 3 antipodal cells
Hence mature angiospermic embryo sac is 8 nucleated & 7 celled

(III) Pollination

KINDS OF POLLINATION ON BASIS OF SOURCE OF POLLEN

AUTOGAMY

(Pollination within same flower). In a normal flower it is rare cause it requires synchrony b/w pollen release & stigma receptivity, stigma & anther should lie close. Plants like viola (common pansy), oxalis, commelina produce 2 types of flowers cleistogamous (closed) & chasmogamous (exposed anther & stigma). Cleistogamous flowers produce assured seed set even in the absence of pollinators.

NEET 2013

GEITNOGAMY

Pollination b/w 2 flowers of same plant. Which is cross pollination cause it requires agent & genetically similar to autogamy.

AIPMT 2014

XENOGAMY

Pollination b/w 2 different plants which brings genetic variation.

Agents of pollination-

Abiotic

Pollination by wind is more common among abiotic agents in which pollen grains should be light, non sticky. Stamen should be well exposed, large often feathery stigma. Wind pollinated flowers often have single ovule in each ovary. Eg- corn cob- the tassels (they actually are stigma & style). It is common in grasses.

AIPMT 2011, 2012

Pollination by water is limited upto 30 genera, mostly monocots. Eg- vallisneria & hydrilla (freshwater), zostera (marine grass). In water hyacinth & water lily, flower emerge out & perform pollination by wind or abiotic (insects). In vallisneria, female flower reaches surface by the long stalk & pollen are released on the surface of water. In seagrass, female flower remains submerged & pollen are of shape- long, ribbon like & released in water carried passively. Pollen are protected by mucilaginous covering from wetting.

NEET 2019

Flower pollinated by wind or air are neither attractive nor produce nectar.

Biotic

Birds(sunbirds & humming birds), primates (lemurs), arboreal(free dwelling) rodents, reptiles (gecko lizard & garden lizard). Bees are dominating biotic pollinating agent. Flowers are adapted to particular species of animal for pollination.

Conditions & necessities-
Flowers should be large, colourful, fragrant, full of nectar. (If flowers are small they are clustered into an inflorescence making them conspicuous) flowers pollinated by flies, beetles secrete foul odours. special rewards should be prepared like nectar, pollen (floral rewards). Special rewards may also include providing safe place to lay eggs. Eg- amorphallus (tallest flower- 6ft) & relation b/w moth & yucca plant where moth deposit its eggs in locule & larvae come out of eggs when seed starts developing. They both can't complete their life cycle without each other.

Outbreeding devices

Developed mechanisms itself by plant to prevent autogamy cause many flowers are hermaphrodite & continuous self pollination leads to inbreeding depression:
1) pollen release & stigma reciptivity are not synchronised.
2) anther & stigma are placed at different position.
3) self incompatibility- rejection of pollen of same genes in response of no formation of pollen tube i.e. no pollen germination.
4) production of unisexual flowers.

If both male & female flower present in same plant (monoecious) like castor, maize —> it prevents autogamy but not geitnogamy but if male & female flowers are present on different plants like in papaya then it prevents both autogamy & geitnogamy.

(NEET 2017)

Pollen-Pistil interaction

If pollen is of light type, pistil accepts it & promotes post pollination events & this recognition is result of dialogue b/w pollen & pistil mediated by chemicals.

NEET 2016

AIPMT 2007

The plants in which pollen shed off at 2 celled stage- the generative cell divides in pollen tube growth. The male gamete enter ovule through micropyle & enters one of the synergids through filiform apparatus. This interaction is a dynamic process. Knowledge gained here would help plant breeder in manipulating pollen pist interaction even in incompatible pollination to get desired hybrids.

Pollen germination can be studied (seen) on sprinkling 10% sugar solution on pollen & observing it after 15-30 min under low power lens of microscope.

In artificial hybridisation the germination of desired pollen & prevention of stigma contamination is very necessary hence emasculation (removal of stamen if flower is bisexual using forceps) & bagging (covering by a bag of butter paper on emasculated flower for prevention) is performed. The female flower buds are bagged before the flowers open.

DOUBLE FERTILISATION

Male gametes enter into cytoplasm of synergid & then perform double fertilisation. 2nd one form PEN (primary endosperm nucleus) & since it involves fusion of 3 haploid nuclei is called triple fusion after which it becomes PEC.

(NEET 2019)

Post fertilisation : structure & events

Events of endosperm & embryo development, maturation of ovule into seed & ovary into fruit.

(I) Endosperm

PEC divides repeatedly to form triploid endospermous tissue filled with reserve food material. The PEN undergoes various nuclear divisions to give rise free nuclei (free nuclear endosperm) & when cell wall gets formed it becomes cellular endosperm. Eg- coconut water —> free nuclear, white kernel —> cellular endosperm.
Endosperm may either be completely consumed (eg- pea, groundnut, beans) before seed maturation or may be consumed during seed germination & persist in mature seed (eg- castor, coconut).

NEET 2016

(II) Embryo

It develops at micropylar end of embryo sac by division of zygote after little amount of endosperm is formed. The early stages of embryo development (embryogeny) are similar in monocot & dicot.
Zygote -> proembryo -> globular -> heart shaped -> mature embryo

DICOT EMBRYO- 2 cots., embryonal axis , epicotyl (portion of embryonal axis above level of cotyledons), plumule + hypocotyl + radicle/ root tip + root cap.

MONOCOT EMBRYO- 1 cotyledons. In grass family cotyledons is called scutellum. Situated one side (lateral) of embryonic axis whose lower & has radical & root cap enclosed in an undifferentiated sheath called coleorrhiza. The portion of the embryonal axis above the lower attachment of scutellum is the epicotyl which have shoot apex & a few leaf primordia enclosed in a hollow foliar structure the coleoptile.

(III) Seed

It is fertilised ovule & final product of sexual reproduction.
Mature seeds may be Non albuminous/non-endospermous (eg- pea, groundnut). Or albuminous(eg- wheat, maize, barley, castor)
In some seed like black pepper & beet, remnants of nucellus are also persistent which is called perisperm.
Integuments of ovules harden as tough protective seed coat.
Micropyle facilitates entry of O_2 & H_2O. As seed matures, H_2O content decreases & it becomes dry (10-15% by mass) due to which it can go under dormancy. The wall of ovary forms wall of fruit (pericarp).
Fruits may be fleshy (guava, orange, mango) or dry (groundnut, mustard).
In few species such as apple, strawberry, cashew, thalamus also contribute to fruit formation i.e. false fruit. Parthenocarpy (as in banana) can be induced by application of growth hormones.

ADVANTAGES OF SEEDS-

- They are dependable on water
- They have adaptive features for dispersal to new habitats & colonise in other areas.
- They cause having food reserve, serve plant until it is capable of photosynthesis.
- Generate new genetic combinations leading to variation.
- They are basis of agriculture & their dormancy helps in storage of seed.

A lupine lupinus arcticus excavated from arctic tundras germinated & flowered after 10,000 years of dormancy (oldest). Recently a 20p0 yr old viable seed is of date palm phoenix dactylifera discovered during archeological excavation at king herod's palace near dead sea.

Apomixis & polyembryony

Form of asexual reproduction that mimics sexual reproduction & i.e. production of seeds without fertilisation (takes place in astersceas & grasses). It can take place if diploid egg cell is formed without reduction division & develops into embryo or as in citrus, mango some of nucellar cells surrounding embryosac start dividing, protrude into embryosac & develop into embryo where each ovule contain many embryos (polyembryony)

Apomixis in agriculture

One of problems of hybrids is that they need to be produced every year cause plants in progeny segregates & do not mantain hybrid characters which will be costly to farmers. If these hybrids are made into apomicts (no segregation) & farmers can use the hybrid seeds to raise new crop every year and does not have to buy hybrid seeds every year. Cause of importance of apomixis in hybrid seed industry active research is going to transfer apomictic genes into hybrid varieties.

NCERT Diagrams for reference

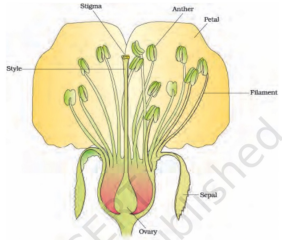


Figure 2.1 A diagrammatic representation of L.S. of a flower

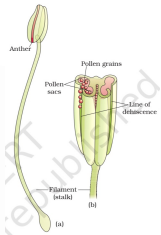


Figure 2.2 (a) A typical stamen; (b) three-dimensional cut section of an anther

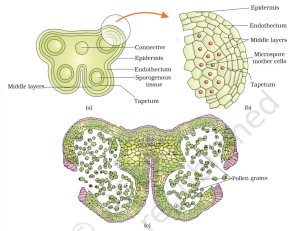


Figure 2.3 (a) Transverse section of a young anther; (b) Enlarged view of one microsporangium showing wall layers; (c) A mature dehisced anther

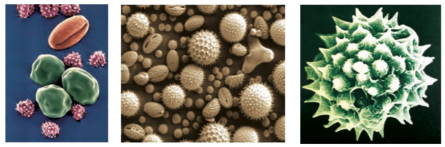


Figure 2.4 Scanning electron micrographs of a few pollen grains

Figure 2.6 Pollen products

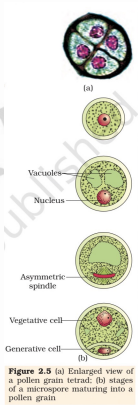


Figure 2.5 (a) Enlarged view of a pollen grain tetrad; (b) stages of a microspore maturing into a pollen grain

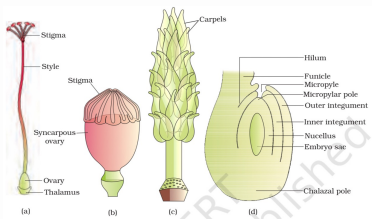


Figure 2.7 (a) A dissected flower of *Hibiscus* showing pistil (other floral parts have been removed); (b) Multicarpellary, syncarpous pistil of *Papaver*; (c) A multicarpellary, apocarpous gynoecium of *Michelia*; (d) A diagrammatic view of a typical anatropous ovule

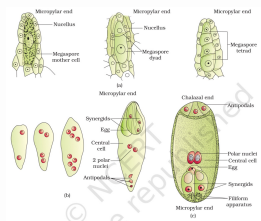


Figure 2.8 (a) Parts of the ovule showing a large megaspore mother cell; a dyad and a tetrad of megaspores; (b) 2, 4, and 8-nucleate stages of embryo sac and a mature embryo sac; (c) A diagrammatic representation of the mature embryo sac.

Figure 2.10 A wind-pollinated plant showing compact inflorescence and well-exposed stamens

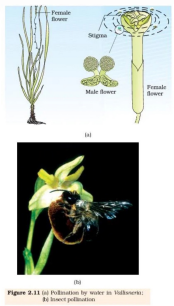


Figure 2.11 (a) Pollination by water in Vallisneria; (b) Insect pollination

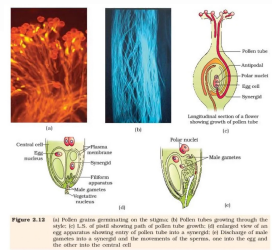
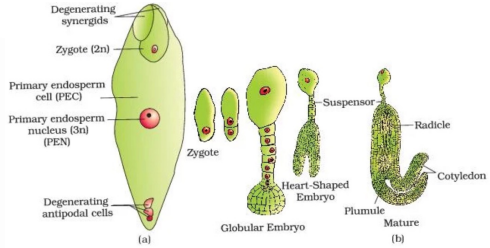


Figure 2.12 (a) Pollen grains germinating on the stigma; (b) Pollen tubes growing through the style; (c) L.S. of pistil showing path of pollen tube growth; (d) enlarged view of an egg apparatus showing entry of pollen tube into a synergid; (e) Discharge of male gametes into a synergid and the movements of the sperms, one into the egg and the other into the central cell

Figure 2.9 (a) Self-pollinated flowers; (b) Cross pollinated flowers; (c) Cleistogamous flowers



ture 2.13 (a) Fertilised embryo sac showing zygote and Primary Endosperm Nucleus (PEN); (b) Stages in embryo development in a dicot [shown in reduced size as compared to (a)]

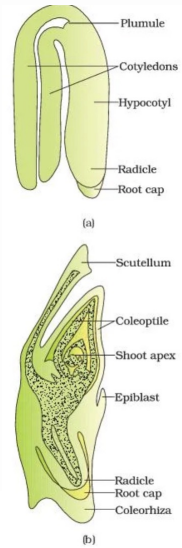


Figure 2.14 (a) A typical dicot embryo; (b) L.S. of an embryo of grass

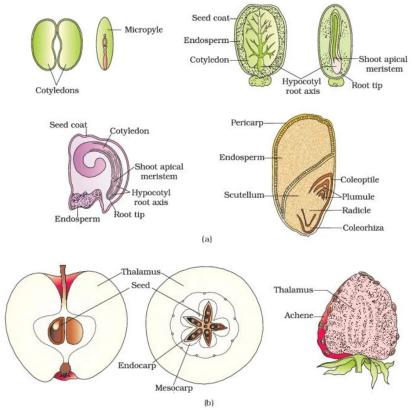


Figure 2.15 (a) Structure of some seeds. (b) False fruits of apple and strawberry

Human reproduction

Transfer of sperms in female genital tract- insemination.
After zygote formation, blastocyst forms & develops which attaches to uterine wall.
Embryonic development— gestation
Delivery of baby — parturation

The male reproductive system

Located in pelvis & consists of pair of testis + accessory duct + glands + external genitalia.
Testis are located outside abdomen to lower temp. By 2- 2.5°C for spermatogenesis.
Adult testis is oval , 4-5 cm in length, 2-3 cm in width & each testis have 250 compartments (testicular lobules) each lobule have 1-3 highly coiled seminiferous tubules which contain 2 type of cells—> male germ cell/spermatogonia (males sperms) & sertoli cells(provide nutrition to former). External to seminiferous tubules is interstitial space having blood vessels & interstitial/leydig cells which secrete hormones (androgens) & immunological competent cells.

AIPMT 2011

AIPMT 2010

AIPMT 2012

Accessory ducts -> the sperms from seminiferous tubules goes into rete testis then to vasa efferentia then to epididymis (posterior to testis) then vas deferens which loops over bladder & receives duct from seminal vesicle & then open into urethra & then external opening (urethral meatus).
Penis is male external genitalia made up of special tissue help in erection.

NEET 2019
AIPMT 2011

The enlarged end of penis is called glans penis & is covered by foreskin.
Accessory gland -> paired seminal vesicle, a prostate, paired bulbourethral glands.
Secretion of bulbourethral gland help in lubrication of penis.

rich in fructose, calcium and certain enzymes (AIPMT 2012)

The female reproductive system

Located in pelvis & consist of pair ovaries + oviduct + uterus + cervix + vagina + ext. genitalia
These all things along with mammary gland support ovulation, fertilisation, pregnancy, birth, child care.
Each ovary (primary sex organ) is about 2-4 cm in length & attached to pelvic wall & uterus by ligaments & is covered by epithelium (thin) & its cavity is ovarian stroma divided into peripheral cortex & inner medulla.

Accessory ducts -> oviduct/ fallopian tube, uterus, vagina & oviduct = 10-12 cm.
The closer part of oviduct to ovary is funnel shaped infundibulum & its edges possess fimbrae (help in collection of ovum). Infundibulum leads to wider part of oviduct, ampulla & last part, isthmus (with narrow lumen) & then joins uterus which is also called womb. (Like inverted pear) & supported by ligaments attached to pelvic wall & it opens into vagina through cervix (narrow). (Cavity of cervix / cervical canal + vagina = birth canal)

(AIPMT 2010)

Three layers of uterus-> external membranous perimetrium, myometrium (smooth muscles), endometrium (goes under changes during menstruation) myometrium exhibits strong contractions during delivery of baby.
External genitalia-> mons pubis (cushion of fatty tissue covered by skin, pubis hair + labia majora (fleshy folds which extend down from mons pubis & surround vaginal opening + labia minora (paired folds under majora) + hymen (membrane partially covers vaginal opening & breaks in first coitus but not absolute proof of virginity) + clitoris (finger like which lies at the upper junction of two labia minora & above the urethral opening. Hymen can also break due to insertion of vaginal tampon.

MAMMARY GLANDS

Paired structure (breasts) contain glandular tissue + fat. Glandular tissue of each breast is divided into 15-20 mammary lobes. Containing alveoli cells which secrete milk & get stored in cavity (lumen of alveoli). It open into mammary tubules & tubule of each lobe join to form mammary duct & several mammary duct join to form ampulla connected to lactiferous duct through which milk is sucked out.

GAMETOGENESIS

Spermatogenesis

Immature male germ cells (spermatogonia / spermatogonium) produce sperms by spermatogenesis which divide mitotically in which each cell contain 46 chr (diploid).
Some spermatogonia called primary spermatocytes undergo meiosis periodically forms 2 haploid secondary spermatocytes which undergo 2nd meiosis & form 4 haploid spermatids transformed into spermatozoa (sperms) by process called spermiogenesis after which sperm heads become embedded in sertoli cells & they are released from seminiferous tubule by spermiation process.

NEET 2015

AIPMT 2008

It starts at puberty due to high secretion of gonadotropin releasing hormone (GnRH) —> hypothalamic hormone. GnRH acts on anterior pituitary & stimulates secretion of LH (leutinising hormone) & FSH (follicle stimulating hormone). LH act on leydig cell & stimulate secretion of androgens & FSH acts on sertoli cells which help in spermiogenesis. Androgens stimulate the process of spermatogenesis.

Structure of sperm- head + neck + middle piece + tail, plasma memb covering whole body. It contains elongated haploid nucleus whose anterior portion is covered by caplike acrosome (enzyme help in fertilisation) & middle piece contains mitochondria. 200- 30l M sperms are released during single coitus & atleast 60% have normal shape & size at least 40% of them must show vigorous motility. Male accessory ducts & glands maintain by testicular hormones (androgens). Seminal plasma + sperms = semen

AIPMT 2010

Oogenesis

Initiate during embryonic stage when a couple of million gamete mother cells (oogonium) are formed within each ovary. No oogonium are added after birth. These cell start prophase I of division & get arrested temporarily called primary oocyte which are then surrounded by granulosa cells & called primary follicle. Many of which degenerate uptil puberty hence only 60,000 - 80,000 primary follicle is left in each ovary. They are further surrounded by more granulosa cells & a new theca & are calles secondary follicles. Which are further developed to tertiary follicle characterised by fluid filled cavity antrum.

The theca develops into theca externa & interna & at this stage primary oocyte within tertiary follicle grows in size & completes meiosis I —> then unequal division resulting in haploid secondary oocytes & a tine first polar body . Secondary oocyte retains bulk of nutrient rich cytoplasm of primary oocyte. The tertiary follicle changes into mature follicle/ graffian follicle. Secondary oocyte forms a new membrane called zona pellucida surroundingit. The Graafian follicle then ruptures to release the secondary oocyte i.e. the ovum from the ovary by the process of ovulation.

NEET 2020

Menstrual cycle

Reproductive cycle of female primates
MENARCH- first menstruation.
In humans menstruation is repeated after 28/29 days & one ovum is released (ovulation) during middle of each menstrual cycle. Menstrual flow lasts for 3-5 days which occurs due to breakdown of endometrium & its blood vessels. Lack of menstruation indicates pregnancy or stress, poor health.

Neet 2018

The menstrual phase is followed by the follicular phase during which primary follicles grow in ovary to fully mature graafian follicle & at same time endometrium of uterus regenerates through proliferation which are caused by pituitary/ ovarian hormones. LH & FSH release increase during follicular phase & stimulates follicular development & secretion of estrogen from growing follicles.

NEET 2020

LH & FSH attain peak in 14 days (middle of cycle) which causes LH surge i.e. rupture of Graafian follicle & thus ovum releases.
Ovulation is followed by luteal phase in which graafian follicle transform as corpus luteum secreting high amount of progesterone essential for maintenance of endometrium. In absence of fertilisation corpus luteum degenerates causing disintegration of endometrium. It ceases at the age of 50 (MENOPAUSE)

NEET 2014

Fertilisation & implantation

Fertilisation takes place in ampullary region of oviduct & it can only occur if ovum & sperm are transported simultaneously to the ampullary region hence all copulation does not lead to pregnancy/fertilisation.
During fertilisation sperm comes in contact with zona pellucida layer of ovum & induces changes in membrane that blocks entry of additional sperms.

NEET 2016

The secretion of acrosome helps sperm to reach cytoplasm of ovum which induces the completion of the meiosis of secondary oocyte & its division is also unequal resulting in 2nd polar body & haploid ovum (ootid) which fuses with sperm.

NEET 2019, 22

The mitotic division starts as zygote moves through isthmus of oviduct called cleavage towards uterus & forms 2,4,8,16 daughter cells (blastomeres). Embryo with 8-16 blastomeres is called morula which further transforms into blastocyst. Blastomeres in blastocyst are arranged as outer layer (trophoblast) & inner group of cell (inner cell mass) out of which trophoblast gets attached to endometrium & inner cell mass get differentiated as embryo. The uterine cells divide rapidly & covers blastocyst hence it becomes embedded in endometrium.

Pregnancy & embryonic development

After implantation chorionic villi appear on trophoblast, surrounded by uterine tissue & maternal blood. Chorionic villi gets interdigitated with uterine tissue to form placenta. Which is connected to embryo through umbilical cord (helps in transport). Placenta also acts as endocrine tissue producing human chorionic gonadotropin (hCG), human placental lactogen (hPL), estrogens, progesterone.

hCG, hPL & relaxin are produced in women only during pregnancy & during pregnancy & during it other endocrine hormones also increase in blood supporting fetal growth, metabolic changes & maintaining pregnancy.

Immediately after implantation inner cell mass differentiate into endoderm, ectoderm & mesoderm & they have some special cells called stem cells having potency to give rise to all tissues and organs.

In the first month heart is formed & starts beating (first sign of growing foetus). & in 2nd month limbs & digits are formed. By the end of 12 weeks (first trimester) major organ system are formed limbs & external genitalia are well developed. The first movement & appearance of hair on head is found in 5th month. By end of 24 weeks (end of 2nd trimester) body is covered with fine hair, eyelid separate, eyelashes formed & by the end of 9th month foetus is fully developed.

Parturation & lactation

Duration of human pregnancy/gestation period is 9 months. Parturation means contraction of uterus & release of foetus (delivery) which is induced by a complex neuroendocrine mechanism. When foetus is fully developed it induce mild contraction in uterus called foetal ejection reflex which triggers release of oxytocin which acts on uterine muscle causes stronger contraction & stimulates further secretion. This leads to expulsion of baby out of uterus through birth canal & placenta is also expelled out of uterus.

NEET 2015

Mammary glands of mother undergo differentiation during pregnancy & starts produce milk by end of pregnancy by process called lactation & milk produced in initial few days of lactation is called colostrum containing antibodies necessary for resistance of new borns & it is recommended for bringing up healthy baby.

NCERT Diagrams for reference

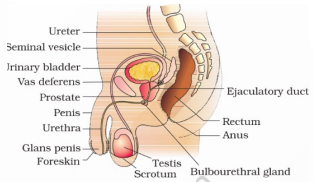


Figure 3.1(a) Diagrammatic sectional view of male pelvis showing reproductive system

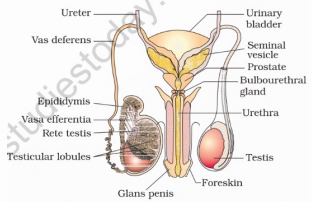


Figure 3.1(b) Diagrammatic view of male reproductive system (part of testis is open to show inner details)

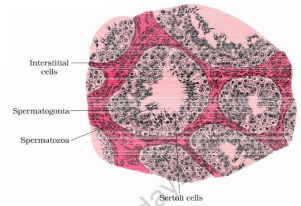


Figure 3.2 ...ic sectional view of seminiferous tubule

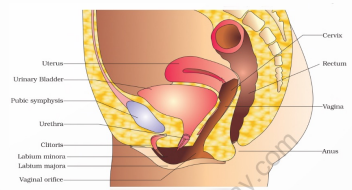


Figure 3.3 (a) Diagrammatic sectional view of female pelvis showing reproductive system

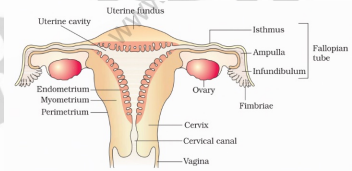


Figure 3.3 (b) Diagrammatic sectional view of the female reproductive system

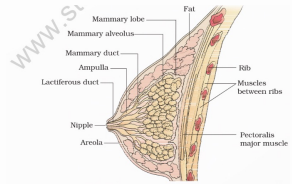


Figure 3.4 A diagrammatic sectional view of Mammary gland

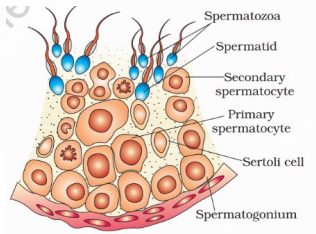


Figure 3.5 Diagrammatic sectional view of a seminiferous tubule (enlarged)

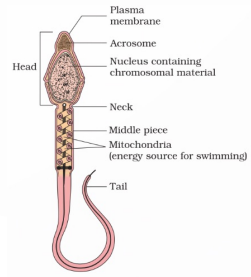


Figure 3.6 Structure of a sperm

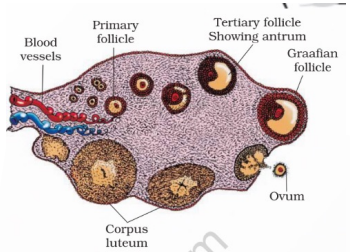


Figure 3.7 Diagrammatic Section view of ovary

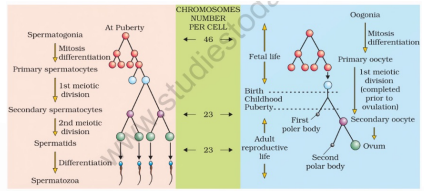


Figure 3.8 Schematic representation of (a) Spermatogenesis; (b) Oogenesis

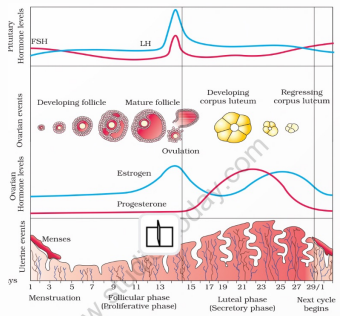


Figure 3.9 Diagrammatic presenation of various events during a menstrual cycle

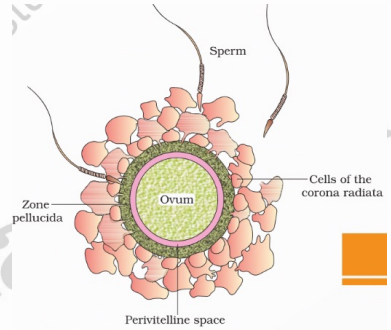


Figure 3.10 Ovum surrounded by few sperms

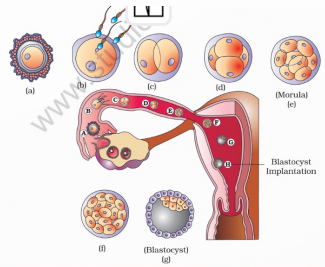


Figure 3.11 Transport of ovum, fertilisation and passage of growing embryo through fallopian tube

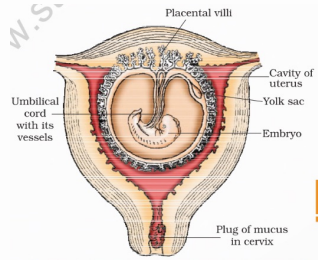


Figure 3.12 The human foetus within the uterus

Reproductive health

According to WHO, Reproductive health means a total well being in all aspect of reproduction i.e. physical, emotional, behavioural, social.

Reproductive health- problems & strategies

Programmes called family planning were initiated in 1951 for attaining proper & total reproductive health & also programmes like reproductive and child health care (RCH) programmes. It's major tasks are following:-

- Awareness is being created by agencies using audiovisual & print media
- Educating people for contraceptive, care of pregnant mothers, post natal care of mother & child, importance of child breast feeding, sexual racism.
- These require infrastructure facilities, expertise, material support. It is essential to provide medical assistance for problems like pregnancy, delivery, STD, abortion, contraception, infertility, menstrual problem.
- Introduction of sex education in schools & proper information about reproductive organs, adolescence, safe hygienic sex, STS, AIDS, etc.
- Awareness of problems due to population, sex abuse, sex-related crime.
- Implementation of better techniques & new strategies. Eg- Ban on amniocentesis for sex determination, massive child immunisation

In amniocentesis, amniotic fluid of developing foetus is taken to analyse & it can be used to detect presence of genetic disorders like Down syndrome, haemophilia, sickle cell anaemia, etc. & determine the survivability of the foetus.
Saheli - an oral contraceptives for females was developed by scientists at central drug research institute (CDRI) in Lucknow.

Population stabilisation & birth control

Increase in population explosively impact on increased health facilities along with better living conditions & reasons may be decline in death rate, maternal mortality rate (MMR) & infant mortality rate (IMR) & increase in no. Of people in reproducible age.

World population- 2 billion (2000M) in 1900, 6b in 2000, 7.2b in 2011.
Indian population- 250M in 1950, nearly 1b in 2000, 1.2 b in may 2011.

Through reproductive child health (RCH) Programme we can reduce population growth but its marginal.acc. To 2011 census, population growth rate was < 2% i.e. 20/100p/year & increase in this rate will cause scarcity of necessity amenities.

Some initiatives -> hum do hamare do slogan on posters, many urban couples have adopted an 'one child norm' & statuary raising of marriageable age so that couple get concerned.

Contraceptives

IDEAL CONTRACEPTIVES

User friendly, easily available, reversible, effective, no side effects, does not interfere with sexual drive/desire.

They are not regular requirement for maintenance of reproductive health.

CATEGORIES OF CONTRACEPTIVES

Natural/traditional barrier, IUD's , oral contraceptives injectables, implants & surgical methods.

Natural methods

PERIODIC ABSTINENCE

Avoiding coitus from day 10 to 17 of menstrual cycle when ovulation is expected i.e. avoiding coitus in fertile period.

WITHDRAWAL/ COITUS INTERRUPTUS

Removal of penis before ejaculation.

LACTATIONAL AMENORRHEA

Performing coitus during period of intense lactation following parturation cause at that time cycle do not continue. Its side effects is nill & chances of failure is high.

→ NEET 2019, 2020

Barrier methods

CONDOMS

Latex/rubber sheath used to cover penis or vagina & cervix & can be self inserted (privacy) & disposable & also prevent from STI, AIDS.
Nirodh is a popular brand of condoms for male.

DIAPHRAGMS, CERVICAL CAPS, VAULTS

Made of rubber & cover the cervix & blocks entry of sperms. They are reusable & for effective contraceptive results, spermicidal creams, jellies & foams are also used with it.

Intra uterine devices

Inserted by doctors/ expert nurses in vagina & available as non medicated IUD's (eg- lippes loop), cu releasing IUD (Cu7, CuT, multiload 375) & hormone releasing IUD (Progestasert, LNG-20) which makes uterus unsuitable for implantation & cervix hostile to the sperms. The Cu ions supress sperm motility & IUD increase phagocytosis of sperms within uterus.
These are ideal contraceptive for female to delay pregnancy of space b/w children & one of the most used in india.

NEET 2019

Oral contraceptive pills

Doses of progesterone or progesterone & estrogen combination.
Taken daily for 21 days starting within first 5 days of cycle. After a gap of 7 days (during which menstruation occur) it has to be repeated till female desires to prevent conception.
They inhibit ovulation, implantation & after quality of cervical mucus to prevent / retard entry of sperms. Well accepted by females & have less side effects.
Saheli is a non steroidal & once a week pill.

Injectibles

Progesterone or its combination with estrogen are injected or implanted under the skin. Their effect last long upto 72 hours of coitus & found very effective as emergency contraceptive & used to avoid possible pregnancy due to rape or unprotected sex.

Surgical methods/ sterilisation

It blocks the gamete transport. Its vasectomy in male in which vas deferens is tied up thr' small incision on scrotum & in tubectomy oviduct is tied up thr' small incision in the abdomen or through vagina.
Its a permanent solution for preventing pregnancy & its irreversible.

NEET 2013

Infertility in male-

It is due to inability to inseminate or low sperm count which are fixed by artificial insemination (AI) where sperm from donor/ husband is introduced in vagina or uterus (intrauterine insemination).
Emotional religious & social factors are also deterrents in adoption of these methods & out law permit legal adoption as best method to have children.

MTPs are Safe during 1st trimester but risky in 2nd trimester (AIPMT 2011)

Examples of STDs
- AIDS
- Hepatitis
- Syphilis
- Gonorrhea

→ NEET 2020

NCERT Diagrams for reference

Figure 4.1(a) Condom for male

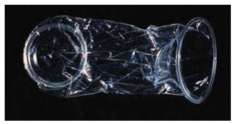


Figure 4.1(b) Condom for female

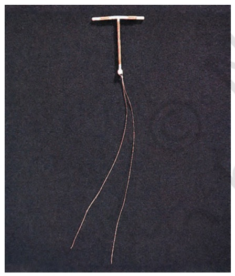


Figure 4.2. Copper T (CuT)

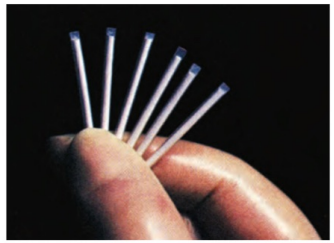


Figure 4.3 Implants

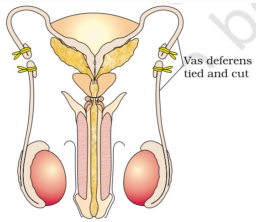


Figure 4.4 (a) Vasectomy

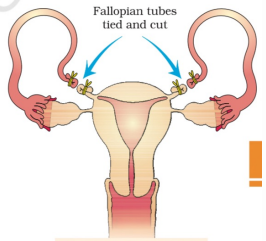


Figure 4.4 (b) Tubectomy

Principles of inheritance and variation

Sahiwal cows of punjab were obtained from wild varieties of cows

Alleles → alternative forms of gene – NEET 2015

Mendels laws of inheritance — NEET 2017

Mendel studied 7 pair of contrasting characters on pisum sativum (garden pea) for 7 years (1856- 1863). For his hybridisation experiment he obtained true breeding line. (He crossed tall plants for several generation & eliminated short. For which he performed continuous self pollination & stable trait inheritance & expression for several generation was observed. He selected total 14 true breeding pea plant varieties.

NEET 2020

Inheritance of one gene (monohybrid cross)

Only one character/gene is studied.
By this cross he concluded that the trait which is expressed in F1 generation is dominant & the one expressed in F2 is recessive.
On selfing 2 short plants he obtained all short plants hence he concluded that it is a homozygous condition but there were 2 cases in 75% tall plants.

NEET 2016

The conclusion is that something being stably passed down unchanged from parents through offsprings through gametes which he called factors. Factors were later identified as genes i.e. units of inheritance.
Punette square - graphical representation to calculate probability of all possible genotype. It was given by british geniticist RC Punette.

TEST CROSS

It was conducted by the mendel to detect the zygosity i.e. homozygous or heterozygous of any plant in which the expressed traits of F2 gen. (75%) is crossed with the homozygous recessive parent.
Eg- in pea plant violet colour is dominant. If the heterozygous dominant is crossed with recessive parent then 50% white & 50% violet are obtained. If homozygous violet is crossed with recessive parent the 100% violet are obtained.

AIPMT 2012

LAW OF DOMINANCE

Characters controlled by discrete units called factors which occur in pair. In dissimilar pair of factors one member of the pair dominates over the other (recessive).
Monohybrid cross explains expression of only one character in F1 & both in F2 & also explains proportion 3:1 in F2.

LAW OF SEGREGATION

Alleles do not show blending in F1 & both recovered at F2 (segregation of allele is a random process). Hence by gamete formation alleles separate & single gamete contains only 1 trait or allele in which if all gametes are similar in any organism then it is homozygous & if 2 kinds of gametes are formed then organism is heterozygous.

INCOMPLETE DOMINANCE — NEET 2019

It is exception to mendels law. In it the offspring obtained in F1 generation does not resemble with either of the parent ie.e. It may be of medium heighted (blending takes place). Eg- inheritance of flower colour in dog flower / snapdragon/ antirrhinum. & in it the phenotypic & genotypic ration both come as 1:2:1. Another Eg- for starch synthesis in pea plant. (Controlled by 1 gene)
In F1 generation intermediate starch grain is formed.

CO- DOMINANCE — NEET 2015, NEET 2020

It's also an exception to mendels law for monohybrid cross. Eg- blood group because it is an example of multiple allelism i.e. more than 2 alleles of single character. Types of alleles —> IA, IB, i
IA, IB —> IA,IB (AB Blood group) (F1 generation resembles both parents).
Plasma membrane of the red blood cell has sugar polymers. i gene do not produce any sugar & IA & IN produce different types of sugar. If IA & IB are present together they both express their own type of sugar (co dominance).
Dominance is not an autonomous feature of a gene or the product that it has info for.
Multiple allelism can be studied on population.

Inheritance of 2 genes (dihybrid cross)

Phenotypic ratio :- 9:3:3:1 & based on observations made from dihybrid cross he gave following law. AIPMT 2006

LAW OF INDEPENDENT ASSORTMENT

When two pair of traits are combined in a hybrid, segregation of one pair of characters is independnt of the other pair of characters. Simply two different genes are not linked with each other. It holds good when genes are present on non homologous chromosome.

Why mendels work was unrecognised till 1900 after being published in 1865?
Communication was not easy, genes/factor controlled expression of trait & no blending was not accepted for continuous expression seen in nature, use of mathematics, no physical proof was present. De veries, correns & vom tschermark discovered mendels work individually after discovery of chromosome movement in 1902 walter sutton & theodre boverinused chromosome movement to explain mendels law.

Chromosomal theory of inheritance

Given by sutton & boveri which tells that behaviour of chromosome is parallel to behaviour of gene. It was given after discovery of chromosome. It states that chromosome movement describes the gene movement cause chromosome contain gene.

VERIFICATION OF CHROMOSOMAL THEORY OF INHERITANCE WHICH CONTRADICTS THE 3RD LAW OF MENDEL BY TH MORGAN:-
It led to discovery of basis of variation that sex produced.
Performed on fruit fly (drosophila melanogaster), he discovered the basis of variation which several reproduction produce.
He studied sex linked genes, he found that the F2 generation phenotypic ratio obtained was highly deviated significantly 9:3:3:1 & for its explanation he gave following concept.

Linkage & recombination

NEET 2015

He performed dihybrid cross on fruit fly.
LINKAGE- physical association of 2 genes. In it the parental combination is higher i.e. baby will express more of parental characteristics.
RECOMBINATION- non parental combination is higher i.e. baby will express new traits. If genes are present nearer they will inherit together hence linkage takes place & if present away from each other recombination takes place.
Genes on same chromosome- high possibility of parental combination.

AIPMT 2010 Neet 2016

Morgan hybridised yellow bodies, white eyed females & brown bodied, red eyed makes & intercrossed their F1 progeny. He found that the genes white & yellow were tightly linked & showed only 1.3% recombination while white & miniature wing showed 37.2% recombination.

NEET 2019

His student Alfred sturtevant used the frequency of recombination b/w gene pairs on the same chromosome as a measure of distance b/w genes & mapped their position on chromosome. Today many genetic maps are used as a starting point in sequencing of whole genomes as was done in the case of the human genome sequencing project.

Why fruitfly is used for experiments?
Could be grown on simple synthetic medium in lab, they complete life cycle in 2 weeks, single mating produce large no. Of flies, well marked sexual dimorphism, it has many types of hereditary variation that can be seen with low power microscope.

AIPMT 2007

Polygenic inheritance

Eg- height, skin colour in humans which are controlled by more than 2,3 genes hence are called polygenic traits. They may also be influenced by environment. For eg- A,B,C genes control skin colour them (AABBCC —> darkest colour & aabbcc —> lightest colour & heterozygosity- > intermediate

NEET 15,21,22

Pleiotropy

Single gene (pleiotropic gene) exhibit multiple phenotypic expression. It is caused due to effect of a gene on metabolic pathways which contribute towards different phenotypes. Eg- phenylketonuria caused by single gene mutation in gene that codes for enzyme phenylalanine hydroxylase & causes mental retardation & reduction in hair, skin pigmentation.

Sex determination

For humans-	Male - XY (male heterogyosity)	Female - XX
For fruit fly-	Male - XY	Female - XX
For hen/birds-	Male- ZZ	Female - ZW (female heterogyosity)
For grass hopper-	Male - 23 pair (XO)	Female 24 pair (XX)

NEET 2019

Explain XO system of sex determination found in birds.
All eggs bear an additional X chromosome besides the autosome on the other hand some of the sperm bear X chromosome while skme do not (O). Eggs fertilised by sperm having X gives female & if fertilise with not having X become male.

Explain haplodiploid sex determination system in honey bees.
It is characteristic feature such as male produce sperms by mitosis, they do not have father & cannot have sons but have grandfather & can have grandsons. Here in honeybees female is 2n = 32 & male is n = 16 chr.

Mutation

It leads to alteration of DNA sequences—> changes in genotype & phenotype.
Types of mutation:-

Frameshift mutation- loss (deletion) or gain(insertion/ duplication) of gene or bp,

Chromosomal aberration (abnormality) can cause cancer in cells.

Point mutation means change in base pair. Eg- sickle cell anemia.

Mutagens:- chemical & physical factors that induce mutation. Eg- UV radiation.

GENETIC DISORDERS

PEDIGREE ANALYSIS:- analysis of traits in a several of generations of a family is called the pedigree analysis & in it the inheritance of a particular trait is represented in family tree over generation.

Genetic disorder can be either mendelian or chromosomal which are described below in detail.

Colourblindness

Sex linked recessive disorder due to defect in either red or green cone of eye & is due to mutation of gene on X chromosome. Occurs in 8% of males & 0.4% of females cause they have 2X. The son of carrier woman has 50% chance of being colour blind where mother itself is not colour blind (recessive). A daughter will only be colour blind if mother is carrier & father is colour blind. Colourblindness is difficulty in distinguishing red & green colour.

Haemophilia

Sex linked recessive disorder & shows transmission from unaffected carrier female to male progeny. A single protein which is a part of cascade of protein involved in blood clotting is affected. A female can be haemophilic very rarely if her father is haemophilic (very rare at that age) & mother is atleast a carrier. It is found in pedigree of queen victoria.

MENDELIAN DISORDERS

Determined by alteration / mutation of single gene & these are transmitted to offspring on same lines as studied in principles of inheritance which can be studied by pedigree analysis. They may be dominant or recessive & may also be sex linked.
Autosomal dominant- mupyotonic dystrophy;;
Autosomal recessive- sickel cell anaemia.

NEET 2013

Sickel cell anaemia

Autosomal linked recessive trait and transmitted when both parents are carrier (heterozygous). Controlled by single pair of allele, HbA & HbS. HbSHbS —> affected & HbSHbA —> carrier & unaffected.
It occurs due to point mutation at 6th position of amino acid in Beta globulin chain of haemoglobin (single base substitution (A by U) hence from GAG to GUG). Due to which earlier it was coding for glutamic acid now codes for valine and the shape of RBS becomes sickel chaped.

AIPMT 2009
NEET 2020

Phenylketonuria

Inborn error of metabolism & also inherited as autosomal recessive trait. The affected individual lacks an enzyme (phenylalanine hydroxylase) that converts the amino acid phenylalanine into tyrosine. Accumulation of phenyl alanine results in its conversion to phenyl pyruvic acid & other derivatives that causes mental retardation in brain & excreted through urine cause of poor absorption of kidney.

Thalassemia

Autosome linked recessive blood disease & transmitted to offspring when both partners are unaffected carriers. It occurs due to mutation/ deletion resulting jn reduced rate of synthesis of one of the globin chains (alpha & beta chains) that make up haemoglobin due to which abnormal Hb is formed & person is anaemic. It can be divided in alpha thalassemia (alpha chain is affected) & beta thalassemia. Alpha thalassemia is controlled by 2 closely linked genes HBA1 & HBA2 on chromosome 16 of each parent & is observed due to mutation or deletion of one or more of 4 genes. The more gene affected lesser alpha globin molecules produced. Beta thalassemia is controlled by HBB (single gene) on chr 11 of each parent & occurs due to mutation of 1 or both the genes. It differs from sickle cell anaemia because former is a quantitative problem (thalassemia) of synthesising too few globin molecule while latter is a qualitative problem of synthesising an incorrectly functioning globin.

AIPMT 2013

CHROMOSOMAL DISORDERS

Caused due to absence /excess /abnormal arrangement of 1 or more chromosome.

ANEUPLOIDY-
Gain of/loss of a chromosome due to failure of segregation of chromatids during cell division. Eg- Down's syndrome (extra copy of 21 chromosome) & turners syndrome (loss of X chromosome in female).

Rarely, either an additional copy of a chromosome may ne included in an individual or an individual may lack one of any one pair of chromosome these are called trisomy & monosomy of chromosome respectively.

POLYPLOIDY-
Increase in whole set of chromosome due to failure of cytokinesis after telophase of cell division which is seen in plants.

COMMON EXAMPLES OF CHROMOSOMAL DISORDER:-

Down's syndrome-

Due to presence of an additional copy of the chromosome no. 21 (trisomy of 21). Discovered by langdon Down in 1866
Symptoms- short statured with small round head, furrowed tongue, partially open mouth, palm is broad, characteristic palm crease, physical, psychomotor & mental development is retarded.

NEET 2013, 17

Klinefelter's syndrome

Due to presence of of additional copy of X - chromosome resulting into a karyotype 47, XXY. Such individual have overall masculine development however feminine development (development of breast i.e. gynaecomastia) is also expressed. Such individuals are sterile.

NEET '19

Turner's syndrome

Due to absence of one of X chr i.e. 45 with XO. such females are sterile as ovaries are rudimentary besides other features including lack of other sec. sexual characters.

NEET 2014

NCERT Diagrams for reference

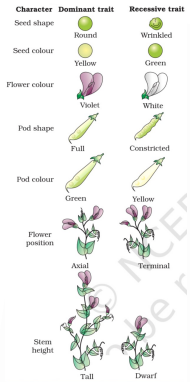


Figure 5.1 Seven pairs of contrasting traits in pea plant studied by Mendel

Table 5.1: Contrasting Traits Studied by Mendel in Pea

S.No.	Characters	Contrasting Traits
1.	Stem height	Tall/dwarf
2.	Flower colour	Violet/white
3.	Flower position	Axial/terminal
4.	Pod shape	Inflated/constricted
5.	Pod colour	Green/yellow
6.	Seed shape	Round/wrinkled
7.	Seed colour	Yellow/green

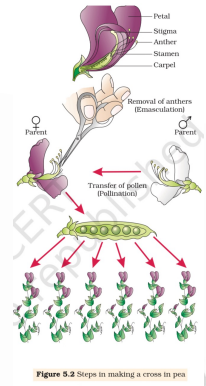


Figure 5.2 Steps in making a cross in pea

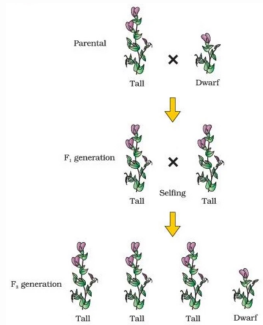


Figure 5.3 Diagrammatic representation of monohybrid cross

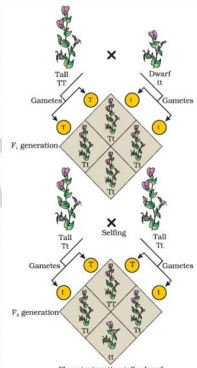


Figure 5.4 A Punnett square used to understand a typical monohybrid cross conducted by Mendel between true-breeding tall plants and true-breeding dwarf plants

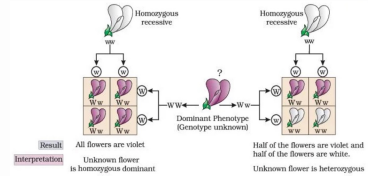


Figure 5.5 Diagrammatic representation of a test cross

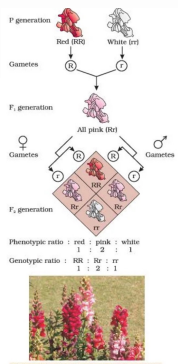


Figure 5.6 Results of monohybrid cross in the plant Snapdragon, where one allele is incompletely dominant over the other allele

Table 5.2: Table Showing the Genetic Basis of Blood Groups in Human Population

Allele from Parent 1	Allele from Parent 2	Genotype of offspring	Blood types of offspring
I^A	I^A	$I^A I^A$	A
I^A	I^B	$I^A I^B$	AB
I^A	i	$I^A i$	A
I^B	I^A	$I^A I^B$	AB
I^B	I^B	$I^B I^B$	B
I^B	i	$I^B i$	B
i	i	$i i$	O

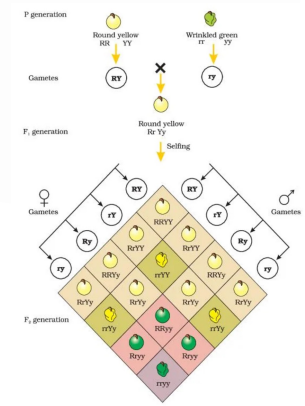


Figure 5.7 Results of a dihybrid cross where the two parents differed in two pairs of contrasting traits: seed colour and seed shape

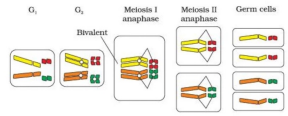


Figure 5.8 Meiosis and germ cell formation in a cell with four chromosomes. Can you see how chromosomes segregate when germ cells are formed?

Table 5.3: A Comparison between the Behaviour of Chromosomes and Genes

A	B
Occur in pairs	*Occur in pairs*
Segregate at the time of gamete formation such that only one of each pair is transmitted to a gamete	*Segregate at gamete formation and only one of each pair is transmitted to a gamete*
Independent pairs segregate independently of each other	*One pair segregates independently of another pair*
Can you tell which of these columns A or B represent the chromosome and which represents the gene? How did you decide?	

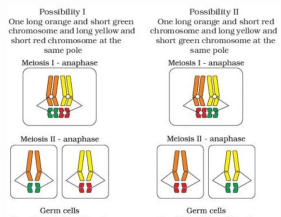


Figure 5.9 Independent assortment of chromosomes

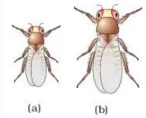


Figure 5.10 *Drosophila melanogaster* (a) Male (b) Female

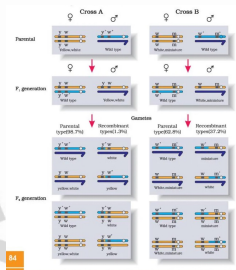


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Figure 5.11 Linkage: Results of two dihybrid crosses conducted by Morgan. Cross A shows crossing between gene y and w; Cross B shows crossing between genes w and m. Here dominant wild type alleles are represented with (+) sign in superscript. Note: The strength of linkage between y and w is higher than w and m.

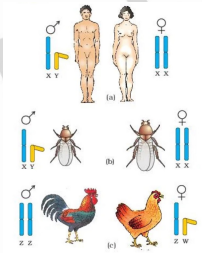

Figure 5.12 Determination of sex by chromosomal differences: (a,b) Both in humans and in *Drosophila*, the female has a pair of XX chromosomes (homogametic) and the male XY (heterogametic) composition; (c) In many birds, female has a pair of dissimilar chromosomes ZW and male two similar ZZ chromosomes

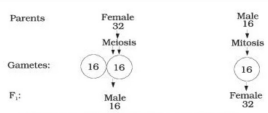

Figure 5.13 Sex determination in honey bee

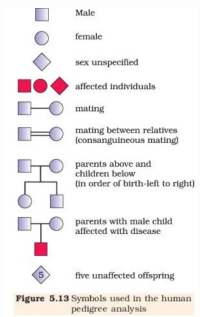

Figure 5.13 Symbols used in the human pedigree analysis

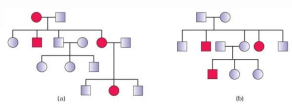

Figure 5.14 Representative pedigree analysis of (a) Autosomal dominant trait (for example: Myotonic dystrophy) (b) Autosomal recessive trait (for example: Sickle-cell anaemia)

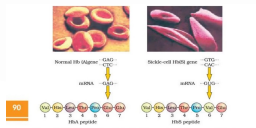

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Figure 5.15 Micrograph of the red blood cells and the amino acid composition of the relevant portion of β-chain of haemoglobin: (a) From a normal individual; (b) From an individual with sickle-cell anaemia

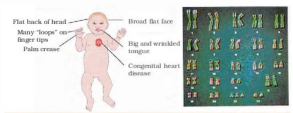
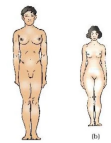


Figure 5.16 *A representative figure showing an individual inflicted with Down's syndrome and the corresponding chromosomes of the individual*



(a) Tall stature with feminised character

(b) Short stature and underdeveloped feminine character

Figure 5.17 Diagrammatic representation of genetic disorders due to sex chromosome composition in humans : (a) Klinefelter Syndrome; (b) Turner's Syndrome

Molecular basis of inheritance

After 100 years of mendelian genetics, the nature of putative genetic material was investigated culminating in the realisation that DNA is the genetic material for majority of organisms. RNA acts as genetic material in some viruses but mostly functions as messenger. It also function as adapter, structural & in some cases catalytic molecule. Formation of RNA from DNA is called transcription and formation of proteins from RNA is called translation.

THE DNA (polymer of deoxyribonucleotides)

Length of DNA = No. of nucleotides present in it (or pair of nucleotides ~ base pair) it is characteristic of organism.
A bacteriophage known as ϕx174 has 5386 nucleotides, bacteriophage lambda has 48502 base pair (bp), E Coli has 4.6 x 10^6 bp & haploid content of human DNA is 3.3 x 10^9 bp.

Structure of polynucleotide chain

Nucleotide

- Nitrogenous bases [purine(A,G) & pyrimidine(C,U,T)] Uracil is present in RNA & Thymine present in DNA. — Neet 2019
- Pentose sugar
- Phosphate group

LINKAGES:-

- N2 base & OH of 1'C of pentose sugar forms N-glycosidic linkage (to form a nucleoside for eg- adenosine, deoxyadenosine, uridine, deoxythymidine)
- Phosphate group and OH of 5'C of nucleoside forms phosphoester linkage & thus forms nucleotide or deoxynucleotide. Its polymer has one end free phosphate moiety at 5' end of sugar & at other end sugar has a free OH Of 3'C (Sugar phosphate backbone). Nitrogenous bases linked to sugar moiety project from the backbone. — AIPMT 2010
- In RNA every nucleotide residue has an additional -OH group present at 2' position in ribose. Thymine is also called 5-methyl uracil. — AIPMT 2008

HISTORY OF DNA

- DNA as acidic substance present in nucleus was forst identified by Friedrich miescher in 1869 named it as nuclein.
- In 1953 James Watson & Francis Crick, based on X-ray diffraction data produced by Maurice Wilkins & Rosalind Franklin proposed double helical structure of DNA. & their hallmark of proposition was base pairing b/w polypeptide chains & was also based upon Erwin Chargaff rule.

$$\frac{A+T}{G+C} = \text{constant} \sim 1$$

The both strands are complementary to each other hence daughter DNA strands are identical to parental DNA.

Salient features of double helix structure:-

1) Made of 2 polynucleotide chains, backbone of sugar phosphate & bases project inside.
2) 2 chains have antiparallel polarity.
3) A pairs with T via 2 hydrogen bond, G pairs with C via 3 hydrogen bonds hence purine always pair with pyrimidine which generates uniform distance b/w strands of helix. — NEET 2020
4) 2 chains are coiled in right handed fashion. Pitch of helix is 3.4nm & 10 base pair are in each turn. Distance b/w a base pair is 0.34 nm
5) CENTRAL DOGMA:-

Central dogma

Packaging of DNA Helix

Length of mammalian DNA = Total bP x dist b/w consecutive bP
= 6.6 x 10^9 x 0.34 x 10^-9
= 2.2 m (greater than dimension of Nucleus i.e. 10^-6 m)

Length of E. Coli DNA = 1.36 mm

In prokaryotes DNA (-ve) + protein (+ve) in a region called nucleoid. The DNA in nucleoid is organised in large loops held by proteins. In eukaryotes histones (+ve & basic) protein are found. A protein acquires charge depending upon the abundance of amino acid residues with charged side chains.

Histones —> lysine + arginine (basic amino acids & both carry +ve charge in their side chains).

NEET 2017

Histones organised to form Histone octamer (eight units= 2 H2A, 2 H2B, 2 H3, 2 H4)

-ve DNA and +ve histone octamer is collectively called as nucleosome (200bp).

Nucleosome constitute repeating unit of structure in nucleus called chromatin.

Nucleosome in chromatin appears Beads on string under electron microscope. It further gets condensed into chromosomes in metaphase. → AIPMT 2011

Packaging of chromatin at higher level requires NHC (Non histone chromosomal proteins).

Chromatin is of 2 types

EUCHROMATIN:- loosely packed chromatin, light stained, transcriptionally active.

HETEROCHROMATIN:-tightly packed, dark stained, inactive.

THE SEARCH FOR GENETIC MATERIAL

Nuclein discovery by meischer & mendel work was at same time. By 1926, molecular basis was reached to quest before it the research was going on chromosome level.

Transforming principal

By friedrich griffith in 1928 on streptococcus pneumoniae (pneumococcus). It was grown on culture plate & some produced smooth/shiny colonies (S) strain due to mucous polysaccharide coat and were VIRULENT. Some produced rough colonies (R) strain which were NON-VIRULENT.

When S strain is given to mice it dies.

When R strain is given to mice it lives.

When heat killed S strain given to mice it lives

When heat killed S strain + R strain (live) is given to mice then mice dies. & he recovered live S bacteria from Dead mice. Hence R strain bacteria have been transformed by heat killed S strain (some transforming principle transformed From S to R). It must be due to transfer of genetic material.

Biochemical characterisation of Transforming principle

By Oswald Avery, colin macleod, maclyn Mccarty (in 1933-44) before it was believed that genetic material was protein. They purified protein, DNA, RNA—> digestion with DNA'ase inhibit transformation hence DNA alone is transformed as hereditary material but not all biologists were convinced. They discovered that protein digesting enzyme (protease) & RNA'ase did not affect transformation.

The genetic material is DNA (Hershey & Chase experiment/ Blenders exp.)

NEET 2017

This unequivocal proof was given by Alfred Hershey & Martha Chase in 1952 based on lysogenic life cycle of E. Coli bacteria (i.e. bacteria does not dies on infection with bacteriophage/ virus but produces more viruses). Some viruses grown in radioactive P hence DNA gets coated with radioactive P32 Cause protein does not have P. It was then infected to bacteria. Viral coats were removed by agitating in blender. Virus particles were removed / separated from bacteria by spinning them in centrifuge. Thus Radioactive Cell (DNA)& non radioactive supernatant is obtained. When some viruses grown in radioactive sulphur S35 then protein gets coated and thus non radioactive cell & radioactive supernatant is obtained.

Thus it was confirmed that Genetic material was DNA & not protein.

Properties of genetic material (DNA vs RNA)

In some viruses RNA is genetic material eg- TMV, QB bacteriophage.
RNA Performs Dynamic functions of messenger and adapter.

Genetic material should fulfil following criteria:-

1) Should be able to generate its replica (replication)
2) should be chemically & structurally stable (throughout all life cycle).
3) should provide scope for slow changes (mutation) required for evolution. (i.e. why virus show high mutation & evolve faster).
4) should be able to express itself in form of Mendelian characters.

RNA, DNA both replicate but protein does not. Stability is ensured in griffith experiment as heating does not affect the stability of DNA.

2 strands of DNA On heating separates and in appropriate condition come together. 2'-OH group present at every nucleotide in RNA is a reactive group & makes RNA liable and easily degradable. RNA is also catalytic hence reactive.

Presence of thymine gives extra stability to DNA (repair in DNA)

RNA Mutates faster than DNA i.e. why viruses having RNA genome having shorter life span mutate & evolve faster.

For transmission of genetic info, RNA is better cause it directly synthesises proteins & for that DNA is dependent on RNA.

Central dogma: DNA → RNA → Protein (NEET 2013)

RNA WORLD!

RNA was first genetic material cause essential life processes (metabolism, translation, splicing) evolved around RNA. It used to act as genetic material as well as catalyst (reactive & unstable). DNA has evolved from RNA & due to double stranded structure of DNA it has got evolved with process of repair.

REPLICATION

By watson & crick as semiconservative DNA replication scheme (one parental, one newly synthesised). "It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for genetic material."- by watson & crick in 1953.

The experimental proof

AIPMT 2000

E.cMatthew meselson & franklin stahl in 1958 on E. coli.
1) they grew E. coli on NH_4Cl as only N2 source for many generation hence N15 incorporated in newly synthesised DNA as well as nitrogen containing compounds which can be distinguished from normal DNA by centrifugation in CsCl (caesium chloride) density gradient because N15 is not radioactive hence only concept of gravity is applicable.
2) then they put cells in NH_4Cl (normal) & took samples at definite intervals & extracted DNA that remained as ds Helix. Various samples separated on CsCl gradients to measure the densities of DNA.
3) after 20 min —> hybrid of intermediate density & after 40 min it is composed of equal amount of this hybrid DNA & light DNA. Similar experiment involving radioactive thymidine was performed on vicia faba (faba beans) by Taylor & Colleagues in 1958 which proved that DNA in chromosome also replicate semiconservatively.

NEET 2016

The machinery & the enzymes

Main enzyme is DNA dependent DNA Polymerase which uses a DNA template to catalyst polymerisation of deoxynucleotides (large no. Of nucleotides in very short time). E. Coli has 4.6 x 10^6 bp & completes the process within 18 minutes i.e. 2000 bp/sec which is fast & high degree of accuracy cause any mistake will lead to mutation. Replication requires high energy (energetically expensive).
Deoxyribonucleoside triphosphates- has dual function i.e. act as substrate & provide energy by breaking 2 terminal phosphate bonds.
Replication occur within small opening of DNA helix (replication fork) cause opening of entire DNA length require lot of energy.
DNA polymerase catalyse polymerisation only in one direction i.e. 5' —> 3' (additional complications).
On one strand (template with polarity 3' —> 5') the replication occurs continuous, while on the other (the template with polarity 5' —> 3'), it is discontinuous. The discontinuously synthesised ones are joined by DNA ligase.
DNA Polymerase cannot initiate process on their own. It initiates at definite regions called origin of replication (cause of which vector is used in rDNA).
In eukaryotes, the replication of DNA takes place at S-phase of cell cycle. A failure in cell division after DNA replication results into polyploidy (a chromosomal anomaly). Hence both should be highly be highly coordinated.

TRANSCRIPTION

Copying genetic information from one strand of the DNA into RNA. Principal of complementarity governs the process (uracil instead of thymine). In transcription only a segment of DNA and only one of the strands is copied into RNA (unlike replication).

Both the strands are not copied because:-
1) if both act as template, they would code for RNA molecule with different sequences (complementarity does not mean identical) & as they code for proteins, the sequence of amino acids in the protein would be different hence would complicate the genetic info transfer machinery.
2) it would form a dsRNA which prevent RNA from being translated & exercise of transcription would become a futile one.

TRANSCRIPTION UNIT & GENE:-
Gene is functional unit of inheritance. The DNA sequence coding for tRNA of rRNA also define a gene. By defining a cistron as a segment of DNA coding for a polypeptide, the structural gene in a transcription unit could be said as monocistronic (in eukaryotes) & polycistronic (in bacteria or prokaryotes). In eukaryotes genes are split, coding sequence or expressed sequences (exons) appear in mature or processed RNA are being interrupted by introns/intervening sequences —> do not appear in mature. The split gene further complicates definition of gene in terms DNA segment. Inheritance of a character is also affected by promoter & regulatory sequences of structural gene. Hence, sometimes the regulatory sequences are loosely defined as regulatory genes. Even though these sequence do not code for any RNA or protein.

TRANSCRIPTION UNIT (promoter + structural gene + terminator)
There is a convention in defining the two strands of the DNA in the structural gene of a transcription unit. Since 2 strands are complementary, DNA dependent RNA polymerase also catalyse polymerisation in 5' —> 3' (single) direction only. Strand with 3' —> 5' polarity act as template (strand). 5' —> 3' strand have same RNA sequence (except thymine & uracil) is displaced during transcription. It does not code for anything but called coding strand. All the reference point while defining a transcription unit is made with coding strand. The promoter is located at 5' end (upstream) of structural gene (with respect to coding strand) which binds with RNA polymerase. Its presence defines coding & template strand, if it is reversed with terminator then the coding & template strand are also reversed. The terminator is at 3' end (downstream) of coding strand. Some additional sequence found upstream & downstream.

TYPES OF RNA & THE PROCESS OF TRANSCRIPTION

In bacteria mRNA provides template, tRNA brings amino acid & reads genetic code, rRNA play structural & catalytic role in translation. All the three types of RNA are required for transcription.
All RNA's are catalysed by RNA polymerase enzyme. It uses nucleoside triphosphate as substrate and polymerises in a template dependent fashion & it also facilitates opening of helix & continues elongation. Only a short stretch of RNA remains bound to the enzyme. As it reaches terminator, nascent RNA & RNA polymerase falls off. The RNA polymerase is only capable of catalysing the process of elongation. It associates transiently with initiation factor (σ) & termination factor (ρ) to initiate & terminate. In bacteria no processing & also since translation & transcription takes place in the same compartment (no separation of cystol & nucleus), many times the translation can begin much before the mRNA is fully transcribed. Thus transcription & translation can be coupled in bacteria.

IN EUKARYOTES (2 COMPLEXITIES):-

1) there are 3 RNA polymerases. The RNA polymerase I transcribes rRNA (28s, 18s, 5.8s), RNA polymerase III transcribes tRNA, 9srRNAs & snRNA (small nuclear RNAs). RNA polymerase II transcribes precursor of mRNA the hnRNA (heterogeneous nuclear RNA). There are atleast 3 RNA polymerase in nucleus (in addition to the RNA polymerase found in organelles).

2) primary transcript contain both exon & intron hence splicing (removal of introns) is needed. HnRNA undergo capping (of unusual nucleotide methyl guanosine triphosphate, at 5' end & tailing (adenylate residues (200-300) at 3' end in template independent manner). Fully processed hnRNA called mRNA & moves out of nucleus for translation. The split gene arrangements represent probably an ancient feature of the genome. The presence of introns is reminiscent of antiquity, and the process of splicing represents the dominance of RNA world.

GENETIC CODE → AIPMT 2003, 2009, NEET 2010, 2013, 2016)

Replication & transcription (1 nucleic acid from another nucleic acid) were based on complementarity but translation requires transfer of genetic info from a polymer of nucleotides to synthesise a polymer of amino acid & neither complementarity exists b/w nucleotide & amino acid nor theoretics. There were evidences to support that change in nucleic acid (genetic material) were responsible for change in amino acid in proteins. George Gamow argued, there are 4 bases—> have to code 20 amino acid, code should constitute combination of bases. Hence code should be made of 3 nucleotides (bold proposition). There are 64 possible codons.

PROOF:- chemical method by Har Gobind Khorana was instrumental in synthesisng RNA molecules with defined combinations of bases (homopolymer and copolymers). Marshall Nirenberg's cell free system for protein synthesis finally helped the code to be deciphered. Severo Ochoa enzyme (polynucleotide phosphorylase) was also helpful in polymerising RNA with defined sequences in a template independent manner (enzymatic synthesis of RNA).

SALIENT FEATURES:-
1) codon is triplet, out of 64, 61 code for amino acid & 3 act as stop codons.
2) some amino acids are coded by more than 1 codon i.e. they are degenerate. Eg- phenylalanine is coded by both UUU & UUC.
3) codon is read in mRNA in a continuous fashion. There are no punctuation.
4) code is nearly universal (from bacteria to us UUU code for Phe).
But some exceptions found in mitochondrial codons & protozoans.
5) AUG (dual function) - act as initiator codon & also codes for methionine (only coded by AUG).
6) UAA, UAG, UGA are stop/terminator codons.

MUTATIONS & GENETIC CODE:-
Eg- sickel cell anaemia -> change of single base pair jn the gene for beta-globulin chain that results in the change of amino acid residue glutamate to valine.
The insertion or deletion of one or two bases changes the reading frame from the point of insertion or deletion referred to as frameshift insertion or deletion mutation.
Insertion or deletion of 3 or its multiple bases insert or delete in one or multiple codon hence one or multiple amino acid and reading frame remains unaltered from that point onwards.

tRNA - THE ADAPTER MOLECULE
Francis Crick postulated the presence of an adapter molecule that would on one hand read the code & on other hand would bind to specific amino acid cause amino acid can't read the code uniquely. tRNA (earlier called sRNA / soluble RNA) was known before genetic code but as an adapter recognised later.
tRNA has an anticodon loop that has bases complementary to the code, and it also has an amino acid acceptor end to which it binds to amino acid. tRNA are specific for each amino acid. For initiation, there is another specific tRNA that is referred to as initiator tRNA. There are no tRNA for stop codons. The secondary structure of tRNA has been depicted that looks like s clover leaf. In actual structure, tRNA is a compact molecule which looks like inverted L.

TRANSLATION

AIPMT 2000 2004

Process of polymerisation of amino acid to polypeptide is known as translation. Amino acid are joined by peptide bonds which require energy for bond formation.
In the first phase amino acid are activated in presence of ATP & linked to cognate tRNA (called charging of tRNA or aminoacylation of tRNA). If 2 such uncharged tRNA are brought together, the formation of peptide bond b/w them would be favoured energetically. Catalyst would enhance bond formation.
Ribosome consist of structural RNAs & 80 different proteins. In inactive state it contains 2 subunits.

When smaller subunit encounters mRNA —> translation starts.
There are 2 sites in larger subunit fir subsequent amino acid to bind (close enough for peptide bond to form).
The ribosome also act as a catalyst (23s rRNA in bacteria is the ribozyme enzyme) for the formation of the peptide bond.
The translation unit in mRNA is flanked by start codon (AUG) & stop codon & codes for polypeptide. mRNA also has untranslated regions (UTS's) present at both 5' end before start codon & at 3' end after stop codon & are required for efficient translation process.

* for initiation, ribosome binds to mRNA at AUG (start) tyat is recognised by only initiator tRNA.
* Ribosome proceeds the elongation phase during which complexes composed of an amino acid linked to tRNA, sequentially bind to the appropriate codon in mRNA By forming complementary base pairs with the tRNA anticodon.
* ribosome moves from codon to codon. Amino acid translated into polypeptide sequences dictated by DNA & represented by mRNA. At the end, a release factor binds to the stop codon, terminating translation & releasing the complete polypeptide frim the ribosome.

REGULATION OF GENE EXPRESSION

Gene expression results in formation of a polypeptide can be regulated at several levels. In eukaryotes:-
1) transcriptional level (formation of primary transcript)
2) processing level (regulation of splicing)
3) transport of mRNA from nucleus to the cytoplasm.
4) translational level.

Genes are expressed to perform function. Eg- beta-galactosidase in E. coli catalyes the hydrolysis of lactose (disaccharide) to galactose & glucose which bacteria use as source of energy. No lactose means no energy source hence no longer synthesis of beta-galactosidase. Hence metabolic, physiological or environmental conditions that regulate expression of gene. The development of embryo is also example of expression of several sets of genes.
In prokaryotes, control of rate of transcriptional initiation is the predominant site for control of gene expression.

In transcription unit, activity of RNA polymerase regulated by interaction with accessory proteins which affect its ability to recognise start sites. Regulatory proteins act both positively (activators) & negatively (repressor). Accessibility of promoter regions of prokaryotes are regulated by interaction of proteins with sequences termed operators. The operator region is adjacent to promoter and in most cases the sequences of the operator bind a repressor protein. Each operon has its specific operator & specific repressor. Eg- Lac operator is present only in the lac operon & it interacts specifically with lac repressor only.

The lac operon

NEET 2013, 2001

Given by Geneticist, Francois jacob & Jacque Monod (biochemist) in which lactose is used as substrate & glucose or galactose cannot act as induced. It is transcriptionally regulated system & in it polycistronic structural gene is regulated by common promoter & regulatory genes. (Such arrangement is common in bacteria & referred as operon). Eg- lac operon, trp operon, ara operon, his operon, val operon

Lac operon consists of one regulatory i gene & 3 structural gene (z,y,a) where i stands for inhibitor not inducer. i gene codes for repressor. Z codes for beta galactosidase, y codes for permease (increases permeability of cell to beta-galactosidase), a encodes for transacetylase.
Lactose is substrate (regulates switch on & off operon). Lactose is termed as inducer & transported into cells through permease.

(A very low level of expression of lac operon bas to be present in the cell all the time otherwise lactose cannot enter the cell). repressor is synthesised from i gene (all the time constitutively) which binds to operator region & prevents RNA polymerase from transcribing operon. In presence of inducer (lactose/ allolactose) repressor is inactivated which allows RNA polymerase access to promoter & transcription proceeds. Regulation of lac operon can also be visualised as regulation of enzyme by its substrate. Regulation by repressor —> negative regulation. Lac operon is under control of positive regulation as well.

HUMAN GENOME PROJECT/ Mega project

It was done to find out complete DNA sequence of human genome. Genetic make up & info lies in DNA sequence (sequence of bases). If two individuals differ, then their DNA sequences should also be different. With genetic engineering it is possible to isolate & clone DNA & determining DNA sequence ; ambitious project of sequencing human genome was launched in 1990. Human genome have 3 x 10^9 bp & cost sequencing —> US$ 3 per bp. Hence total cost would be around 9 billion US$. Further sequences to be stored in typed form in books.
Thus there was need of high speed computation device for data storage & retreive. (Associated with bioinformatics).

GOALS OF HGP:-
1) identify all 20,000-25,000 genes in human DNA.
2) Determine the sequences of the 3 billion chemical base pairs that make up human DNA.
3) Store this information in databases.
4) improve tools for data analysis.
5) transfer related technologies to other sectors, such as industries.
6) address the ethical, legal & social issues (ELSI) that may arise from the project.
13 year project :- coordinated by US department of energy & national institute of health. In early years wellcome trust (UK) became major partner. Contribution came from japan, france, germany, china. Project completed in 2003.
It is important to diagnose, treat and someday prevent the thousands of disorders, DNA sequences that can lead to understanding of their natural capabilities solving health care challenge, agriculture, energy production, environmental remediation.
Many non-human model like bacteria, yeast, caenorhabditis elegans (a free living non pathogenic nematode), drosophila (fruitfly), plants (rice & arabidopsis) have been sequenced.

METHODOLOGIES (2 major approaches)-
1) Expressed sequence tags (ESTs)- identifying all the genes that are expressed as RNA.
2) sequence annotation- blind approach of simply sequencing the whole set of genome that contained all the coding and non coding sequence & later assigning different regions in sequence.
For sequencing:- DNA is isolated, converted into fragments cause of technical limitations in sequencing long pieces, cloned in suitable host (using vectors), resulted in amplification so that it subsequently could be sequenced with ease. Commonly used hosts- bacteria & yeast. The vectors were called BAC (bacterial artificial chromosome) & YAC (yeast artificial chromosome). The fragments were sequenced using automated DNA sequences (worked on the principle of method developed by fredrick sanger. (Also credited for method of determination of amino acid sequence in protein). Sequences were then arranged based on some overlapping regions present in them, which required generation of overlapping fragments for sequencing. (Humanly not possible) so specialised computer program developed. Sequence were annotated & were assigned to each chromosome. The sequence of chromosome 1 was completed only in May 2006 (last of 24 human chromosome 22 autosome & X-Y to be sequenced). Genetic and physical maps on the genome was generated using info on polymorphism of restriction endonuclease recognition sites and some repetitive DNA sequences known as micro satellites.

SALIENT FEATURES OF HUMAN GENOME:-

1) the human genome contains 3164.7 million bp.
2) average gene consists 3000 bases, but sizes vary, largest known human gene —> dystrophin (2.4 M bases).
3) total genes —> 30,000 (lower than estimated 80,000 to 1,40,000) 99.9% nucleotide bases are exact same in people.
4) functions for 50% discovered genes are unknown.
5) less than 2% of the genome codes for proteins.
6) repeated sequences make very large portion of human genome.
7) repetitive sequences are repeated 100-1000 times & have no direct coding functions, but shed light on chromosome structure, dynamics & evolution.
8) chromosome 1 have most genes (2968) & Y has the fewest (231).
9) scientists have identified about 1.4 M locations where single base DNA differences (SNPs - single nucleotide polymorphism/snips) occur in human which promises to revolutionise the process of finding chromosomal locations for disease associated sequences and tracing human history.

APPLICATIONS & FUTURE CHALLENGES:-

Understanding the biological systems & enabling a radially new approach to biology research.
In past, one or few gene at a time we studied but now —> whole genome sequence (broader scale).
We can study all the genes in a genome. Eg- all transcripts in a particular tissue or organ or tumor, or how tens of thousand of genes and proteins work together in interconnected networks to orchestrate the chemistry of life.

AIPMT 2012
NEET 2013

DNA- FINGERPRINTING

Very quick way to compare the DNA sequence of 2 individual (otherwise would be daunting & expensive). It involves identifying difference in some specific regions called repetitive DNA (small stretch of DNA repeats many times).
0.1% of differences in sequence of DNA make every individual unique (phenotypically).
The repetitive DNA is separated from bulk genomic DNA during density gradient centrifugation. (Bulk DNA forms a major peak & satellite DNA as small peaks).
Depending upon base composition (AT or GC rich), length of segment & no. Of repetitive units satellite are classified as microsatellite and minisatellite. Which do not code for protein but form large portion of genome & show high degree of polymorphism (which is basis of fingerprinting).

MERITS OF DNA FINGERPRINTING-

1) DNA from every tissue show same degree of polymorphism hence useful identification tool in forensic applications.
2) polymorphism are inheritable hence basis of paternity testing in case of disputes.

UNDERSTANDING POLYMORPHISM:-

It is basis of genetic mapping of human genome as well as DNA fingerprinting. Polymorphism (variation at genetic level) arises due to mutation. Germ cell mutation does not seriously impair individuals ability to have offspring who can transmit the mutation, it can spread to other people (by sexual reproduction), allelic sequence variation was traditionally called DNA polymorphism if more than one variant (allele) at a locus occurs in human population with a frequency greater than 0.01. (i.e. inheritable mutation is observed in a population at high frequency). It is referred as DNA polymorphism. Probability of such variation in non coding DNA sequence is more as mutation may not have immediate effect in reproductive ability. These keep on accumulating generation after generation from one of the basis of variability /polymorphism. Variety of different polymorphism ranging from single nucleotide change to very large scale changes. In evolution & speciation —> polymorphism play important role.

TECHNIQUE OF DNA FINGERPRINTING:-

By sir Alec Jeffreys. He used a satellite DNA as a probe that shows high degree of polymorphism. (Called as variable no. Of tandem repeats /VNTR) involved southern hybridisation using radio labelled VNTR as probe. It included:-

1) isolation of DNA.
2) Digestion by restriction endonuclease
3) separation by electrophoresis
4) transferring (blotting) of separated DNA fragments to synthetic membrane such as nitrocellulose or nylon.
5) hybridisation using labelled VNTR probe.
6) detection of hybridised DNA Fragments by auto radiography.

NEET 2016

VNTR belongs to a mini-satellite.
A small DNA Sequence is arranged tandemly in many copy no. Which varies from chromosome to chromosome. The no, of repeats show very high degree of polymorphism. As a result size of VNTR varies from 0.1 to 2 kb. After hybridisation with VNTR probe, autoradiogram - gives many bands of different sizes which gives a characteristic pattern for an individual DNA except in monozygotic twins the sensitivity of the technique has been increased by use of PCR (polymerase chain reaction).
DNA from single cell is enough to perform DNA fingerprinting.
It has much wider application such as in determining population diversity currently, many different probes to generate DNA fingerprints.

NCERT Diagrams for reference

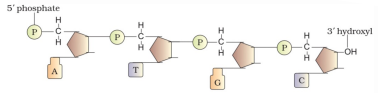


Figure 6.1 A Polynucleotide chain

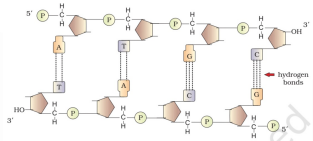


Figure 6.2 Double stranded polynucleotide chain

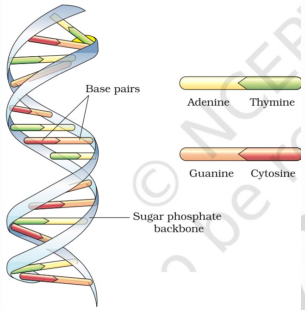


Figure 6.3 DNA double helix

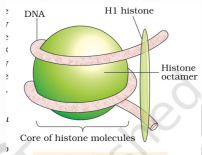


Figure 6.4a Nucleosome

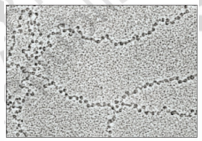


Figure 6.4b EM picture - 'Beads-on-String'

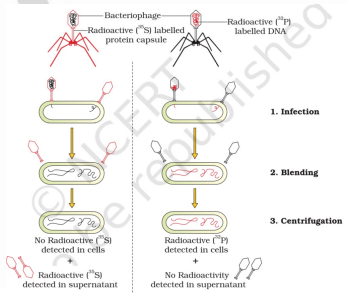


Figure 6.5 The Hershey-Chase experiment

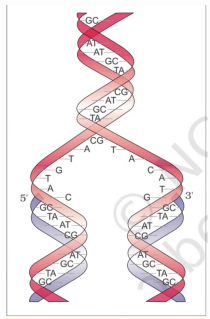


Figure 6.6 Watson-Crick model for semiconservative DNA replication

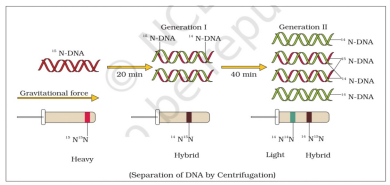


Figure 6.7 Meselson and Stahl's Experiment

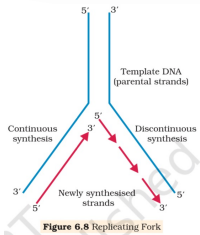


Figure 6.8 Replicating Fork

3′-ATGCATGCATGCATGCATGCATGC-5′ Template Strand

5′-TACGTACGTACGTACGTACGTACG-3′ Coding Strand

Can you now write the sequence of RNA transcribed from the above DNA?

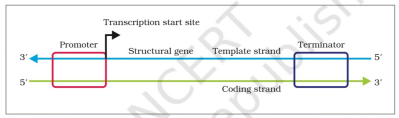


Figure 6.9 Schematic structure of a transcription unit

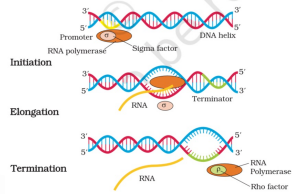


Figure 6.10 Process of Transcription in Bacteria

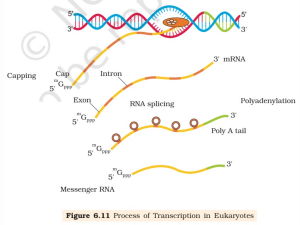


Figure 6.11 Process of Transcription in Eukaryotes

Table 6.1: The Codons for the Various Amino Acids

First position	Second position U	Second position C	Second position A	Second position G	Third position
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

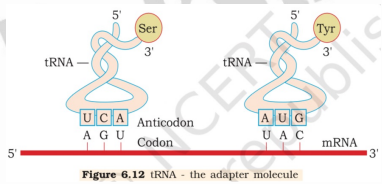


Figure 6.12 tRNA - the adapter molecule

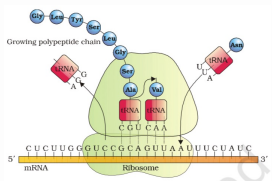


Figure 6.13 Translation

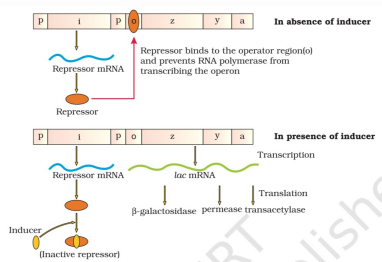


Figure 6.14 The *lac* Operon

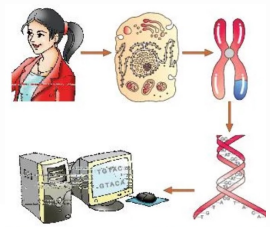


Figure 6.15 A representative diagram of human genome project

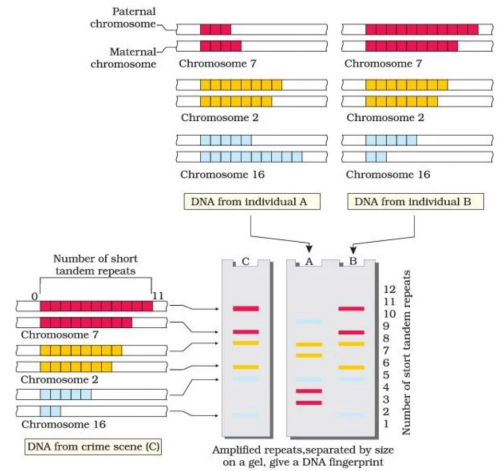


Figure 6.16 Schematic representation of DNA fingerprinting: Few representative chromosomes have been shown to contain different copy number of VNTR. For the sake of understanding different colour schemes have been used to trace the origin of each band in the gel. The two alleles (paternal and maternal) of a chromosome also contain different copy numbers of VNTR. It is clear that the banding pattern of DNA from crime scene matches with individual B, and not with A.

Evolution

In the context of evolution of earth & against the background of evolution of universe itself.

Origin of life

Steller distance are measured in light years. What we see today is an object whose emitted light started its journey millions of years back & from trillions of kilometers away and reaching our eyes now. Hence when we see stars we apparently are peeping into past. Universe is 20 billion years old. Earth was formed 4.5 billion years back.

Big bang theory-

Singular huge explosion took place, universe expanded temp. Came down, H & He formed sometime later & gases condensed under gravity & formed galaxies of present day universe.
Early earth's atmosphere had CO_2 + H_2O vapours + CH_4 + NH_3 which are released from molten mass.

UV Rays broke water to H & O & lighter H_2 escaped. O combined with NH_3 & CH_4 to form H_2O & CO_2 others. Ozone layer was formed & as it cooled rain fall occured & oceans formed. Life appeared 500 million years after the formation of earth i.e. 4 billion years back. Early greek thinkers thought units of life called spores were transferred to different planets including earth. Pansermia is still a favourite idea for some astronomers.

Theory of spontaneous generation-

Life comes from dead & decaying matter like straw, mud, etc.
But louis pasteur proved that life comes only from pre existing life as killed yeast do not flourish in sterelised flask but does in open to air flask. Hence this theory was very soon diminished.

Chemical evolution theory-

AIPMT 2007

Oparin (russia) & haldane (england) proposed that life come from pre existing non living organic molecules (RNA, protein) i.e. formation of diverse organic molecules from inorganic constituents. In 1953, S.L. Miller (american scientist) created electric discharge in closed flask with CH_4, H_2, NH_3, H_2O vapour at 800° C & observed formation of amino acid (sugars, N_2 base, pigment & fat also). Meteorite content also revealed similar compounds indicating similar processes occuring elsewhere in space.

NEET 2020

The first non cellular forms of life came 3 billion years back which would have been giant molecules. (RNA, protein, polysaccharide) these capsules reproduced their molecules. The first cellular form of life did not possibly originate till 2000 million years ago. Which were probably single cells.
BIOGENESIS:- life arose from non living molecules.
GEOLOGICAL TIME SCALE:- eons > eras > periods > epochs > ages

EVOLUTION OF LIFE FORMS- a theory

Theory of special creation

It was religious and was given in 19th century.
HAS 3 CONNOTATIONS:-

- All living beings were created as such.
- Earth is 4000 years old.
- Diversity was and will be same from/ since creation.

Darwin's concept

Based on observations made on sail ship (HMS beagle) round the world.
He concluded that:-
1) life forms share similarities among themselves & to them also who existed in past (ancestors which undergone extinction).
2) there has been gradual evolution & population has built in variation to fulfil the criteria of natural selection.
3) he considered natural fitness similar to reproductive fitness i.e. those who are fitted in environment have more progeny.
Alfred wallace, a naturalist who worked in Malay Archipelago also had same conclusions & apparently new organisms were recognised.
Hence geographical history is equivalent to biological history. All these proved that earth was formed billion of years ago and not thousands.

WHAT ARE EVIDENCES FOR EVOLUTION?

Paleontological evidence

Fossils- remains of hard parts found in rocks (sedimentary).
Different aged rock sediments contain fossils of different life forms who probably died during the formation of particular sediment which represent extinct organisms.
Study of fossils in different sedimentary layers indicates geological period in which they existed & hence new forms of life have arisen at different times in history.

Embryological support for evolution

NEET 2020

(By Ernst Heckel)
Based upon certain features present in embryonic stage & absent in adult. Eg- row of vestigial gill slits present behind head found in embryonic stage & functional in fishes.
This was proved wrong/ disapproved by karl ernst von boer & told that embryos never pass through adult stages of other animals.

Divergent evolution

Eg- whales, bat, cheetah, human all share same pattern of bones of forelimbs (humerus, radius, ulna, carpals & metacarpals) & adapted for different functions hence called divergent evolution & structures are called homologous. It indicates common ancestor. (Other examples- vertebrate hearts or brains, thorn and tendril of bougainvillea & cucurbita.) → AIPMT 2008
Similarities in protein, genes performing a given function also gives clues for common ancestry in diverse organisms.

Convergent evolution

NEET 2013, 2020, 2014, 2016 AIPMT 2012

Eg- wings of butterfly & birds have similar function but anatomically different hence they are analogous (convergent evolution). (Other examples- eyes of octopus & mammal, flippers of penguine & dolphin. One can say that its due to habitat but: sweet potato (root modification) & potato (stem modification).) → NEET 2008
Convergent and divergent evolution is based on comparative anatomy and morphology.

Evolution by natural selection

Case study: In england in 1850s (before industrialisation) no. Of white winged moth were more than no. Of black winged moth cause trees were covered with white lichen & in 1920 (after industrialisation) the ratio was opposite cause trees became black because lichen do not grew in polluted areas.
Predators will spot a moth against a contrasting background hence moths that were able to comouflage themselves survived.

NEET 2015

Evolution by anthropogenic action

Excess use of herbicides/ pesticides has only resulted in selection of resistant varieties in a much lesser time scale. (Also true for microbes)
Hence evolution is a stochastic process based on chance events in nature and chance mutation in organism.

WHAT IS ADAPTIVE RADIATION?

Process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography (habitat) is called adaptive radiation. Eg- (Darwin's finches)- darwin went to galapagos island & found that there were many varieties of small black birds (darwin's finches) in same island (evolved on island itself)
From seed eating features, many other forms with altered bear arose, enabling them to become insectivorous & vegetarian finches.
Eg- (Australian marsupials)- each marsupial is different from other evolved from an ancestral stock in single australian island.
When more than one radiation appeared to have occured in an isolated geographical area (representing different habitats) one can call this convergent evolution.
Eg- (placental mammals)- in australia, appears to be similar to a corresponding marsupial. (Eg- placental wolf & tasmanian wolf (marsupial)).

AIPMT 2010

BIOLOGICAL EVOLUTION

(Based on darwinian principle)
The rate of appearance of new forms is linked to the life cycle or the life span. i.e. if life span is short or reproductive capacity is high (more individual in lesser time). Then chances of variation are very soon visible but as life span increases variation occur with more time. Eg- bacteria & fishes in pond.
So called fitness is based on characteristics which are inherited. Hence there must be a genetic basis for getting selected to evolve.
Fitness is end result of ability to adapt & get selected by nature. Branching descent and natural selection are the two concepts of darwinian theory of evolution.
Before darwin, a french naturalist lamark told that which organ used more develops more but its not believed now. Eg- long neck of giraffe.
Darwin may be influenced by the work of thomas maithus on population.

Natural selection is based upon following observation & facts:-

- Natural resources are limited
- Population are stable in size except seasonal fluctuation.
- Members of population vary in characteristics.
- Variations are inherited. If everybody reproduces maximally the population will grow enormously.
- More population induce competition for resources.
- More no. Of progeny hence more change jn population characteristics.

Mechanism of Evolution

Darwin ignored the Mendel's inheritable factors. In 1st decade of 20th century, hugo de veries introduced mutation on evening prim rose. (Reason for large variation in less time in a population).

Mutation are random & directionless inheritable while darwinian variations are small and directional.

Evolution for darwin was gradual but for deveries mutation caused specialisation & hence called it Saltation (single step large mutation). Studies in population genetics brought clarity.

NEET 2019
AIPMT 2012

HARDY WEINBERG PRINCIPLE

Proposed by GH Hardy, an English mathematician & W. Weinberg, a german physician independently in 1908.
It describes a theoretical situation in which a population is undergoing no evolutionary change.
Gene frequency is frequency with which a particular allele occurs in a population.
Gene frequency suppose to remain fixed and even remain the same through generations in an isolated area.
Thus HW principle states that allele frequency in a population are stable and is constant from generation to generation.
The gene pool (total genes and their alleles in a population) remains constant. (This is genetic equilibrium) & sum total of allelic frequency is one.

5 FACTORS AFFECTING HW PRINCIPLE-

1) Mutation
2) gene flow/ gene migration- movement of alleles from one population to another as a result of inbreeding b/w members of two population.
Removal of alleles from one population or addition of alleles into another population is called gene flow or migration.
3) genetic drift- also known as 'Sewall Wright Effect'. It occurs only by chance. Refers to change in population of alleles in the gene pool.
4) Genetic recombination- new association of alleles is formed in gamete cells.
5) natural selection pressure (population genetics)-
Freq of AA - p2 , Freq of aa - q2 , Freq of Aa - 2Pq
Hence [p2 + 2pq + q2 = 1] —> binomial expansion of (p+q)2
It is possible to calculate all alleles and genotype frequency using expression allele frequency. P+q = 1, genotype freq p2 + q2 + 2pq = 1.
If any of the process mentioned above takes place then evolution will take place (change in no. Of allele) which result to change in freq. hence HW principle fails.

Neet 2016, 2019

FOUNDER EFFECT- (during genetic drift) - if change in allele frequency is so different in the new sample of population that they become a different species the original drifted population becomes founders & it is called as founder effect.

NEET 2016, 2002

A brief account of evolution

> about 2000M years ago (mya) the first cellular forms of life came. Some of which released O2 (similar reaction as light reaction in plants).
> slowly single celled organisms became multicellular life forms.
> by 500 mya invertebrates formed & active. Jawless fish evolved around 350 mya. See weeds & plants existed by 320 mya. Firstly plants invaded the land.
> fish with stout & strong fina could move on land & go back to water about 350 mya.
> in 1938, a fish caught in south africa happened to be a coelocanth which was thought to be extinct.
> lobefins evolved into first amphibians. These were ancestors of frogs & salmanders. Amphibians evolved into reptiles which lay thick shelled eggs and which do not dry up in sun.
> in the next 200 M years or so reptiles of different shapes & sizes dominated on earth.
> giant ferns were present but fell to form coal deposits.
> some of land reptiles went to water to evolve into fish like reptiles 20p mya (eg- ichthyosaurs)
Biggest- tyrannosaurus rex (20 ft height & huge dagger like teeth)
About 65 mya dinosaurs disappeared.
Small sized reptiles of era still exist today.
> first mammals were like shrews (their fossils are small sized).
> when reptiles came down mammals took over this earth.
> there were in south america mammals resembling horse, hippocampus, bear, rabbit. Due to continental drift, when south america formed. North america, these animals were overridden by north american fauna.
> due to same continental drift pouched mammals of Australia survived cause of lack of competition.
Mammals in water- whale, dolphin, seals, seacows.

Origin & evolution of man

> 15 mya primates called Dryopithecus (ape like) & Ramapithecus (man-like) were existing.
> few fossils of man like bone were found in ethopia & tanzania hence before 3-4 mya man like primates walked in eastern africa which were no more taller than 4 ft but walked upright.
> 2 mya australopithecius lived in east african grasslands having stone weapons for protection cause they ate only fruits.
> one were first human like being the hominid and was called homo habilis which had different bones among bones. Their cranial capacity was 650-800 cc & did not eat meat. Their fossils were discovered.
> homoerectus are the one whose fossils were discovered in java in 1891 hence called java ape man. They had large brain around 900 cc. They probably ate meat.
> the neanderthal man with a brain size 1400 cc lived near east & central asia b/w 100,000- 40,000 years back. They used hides to protect them & buried their dead (Cultural).
> Homosapiens arose in Africa during ice age (75,000-10,000). The prehistoric cave art developed about 18,000 years ago. One such cave painting is present at bhimbetka rock shelter in Raisen district of madhya pradesh.
Agriculture came around 10,000 years back & human settlements started.

AIPMT 2013

NCERT Diagrams for reference

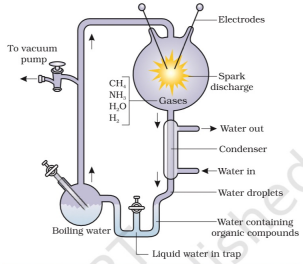


Figure 7.1 Diagrammatic representation of Miller's experiment

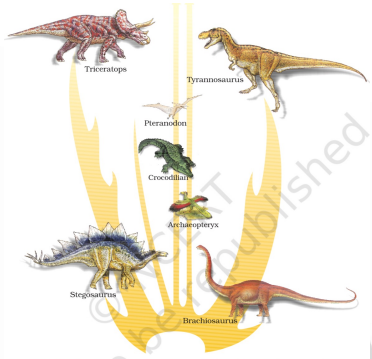


Figure 7.2 A family tree of dinosaurs and their living modern day counterpart organisms li crocodiles and birds

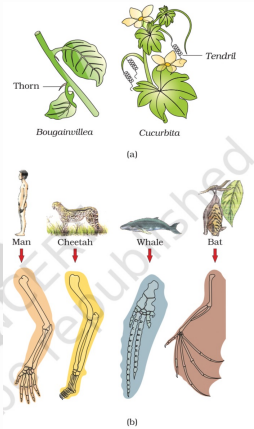


Figure 7.3 Example of homologous organs in (a) Plants and (b) Animals

Figure 7.4 Figure showing white - winged moth and dark - winged moth (melanised) on a tree trunk (a) In unpolluted area (b) In polluted area

Figure 7.5 Variety of beaks of finches that Darwin found in Galapagos Island

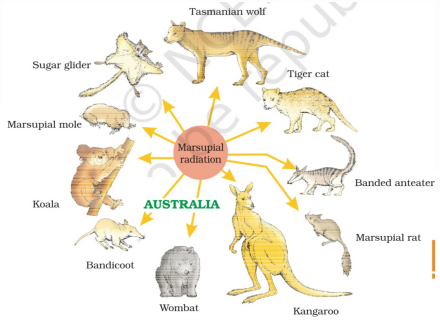


Figure 7.6 Adaptive radiation of marsupials of Australia

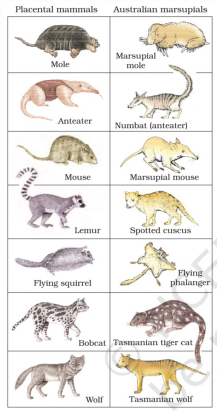
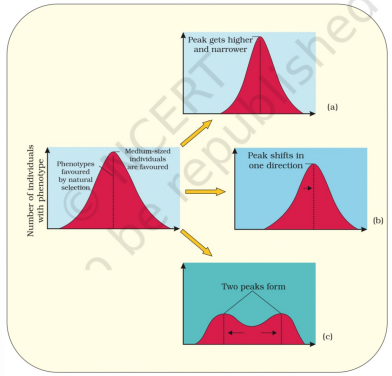


Figure 7.7 Picture showing convergent evolution of Australian Marsupials and placental mammals



7.8 Diagrammatic representation of the operation of natural selection on different traits : (a) Stabilising (b) Directional and (c) Disruptive

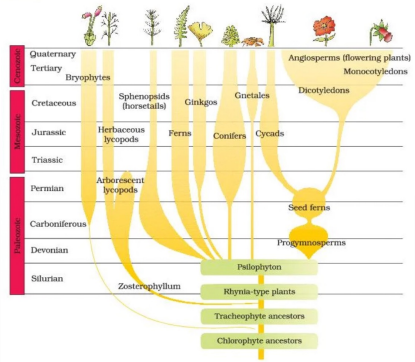


Figure 7.9 A sketch of the evolution of plant forms through geological periods

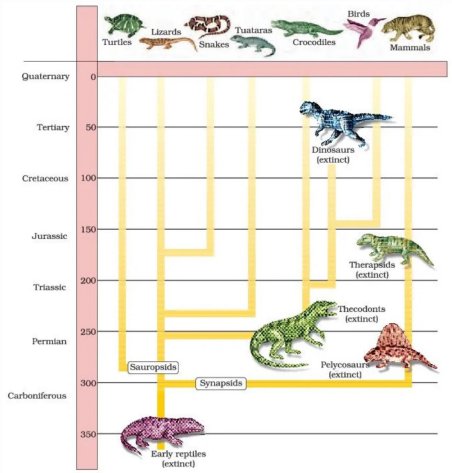


Figure 7.10 Representative evolutionary history of vertebrates through geological periods

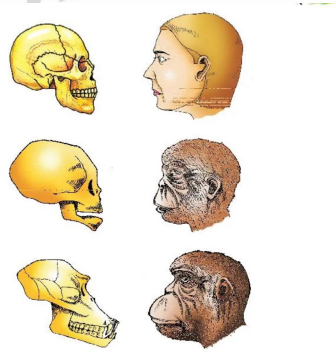


Figure 7.11 A comparison of the skulls of adult modern human being, baby chimpanzee and adult chimpanzee. The skull of baby chimpanzee is more like adult human skull than adult chimpanzee skull

Human Health & Disease

Earlier black bile concept meant hot personality have fevers but proven wrong by William Harvey by telling normal body temperature & blood circulation. It disproved the 'good humor' hypothesis of health. Along with nervous,endocrine & immune system mental state also affect health & is also affected by genetic disorders, infections,lifestyle,economic prosperity,increases life span. Things responsible for maintaining state of health are yoga,vaccination,awareness about disease,lifestyle improvement.
DISEASE —> any body organ is not working properly. They can be infectious(aids) or non infectious(cancer)

Common diseases in humans (Caused by pathogen/parasite)

Typhoid (Salmonella typhi)

Enter into small intestine & transported by blood. Caused by contaminated food.
SYMPTOMS-39-40°C fever, weakness, stomach pain, constipation, headache,loss of appetite. In severe cases intestinal perforations & death may occur. WIDAL TEST. MARY MALLON (typhoid mary) spreaded it to customers by food.

NEET 2019

Pneumonia (Streptococcus pneumonia & Haemophilus influenza bact.)

Alveoli is affected,fluid gets filled in alveoli. Symptoms:- fever,chills,cough,headache ,in severe cases lips,finger nails may turn grey to bluish in color. Spread by aerosols/droplets, sharing utensils with infected. Dysentery,plague & diphtheria are common bacterial diseases.

Common cold (rhino virus)

Infect nose & respiratory tract but not lungs. Symptoms are nasal congestion & discharge, sore throat and hoarseness, cough, headache, tiredness that last for 3-7 days. Droplets or infected object can spread as it is most infectious.

Malaria (plasmodium protozoa)

Eg- p. Vivax, p. Malaria, p. Falciparum causes different malaria. Malignant malaria caused by plasmodium falciparum is most serious and can be fatal.
Life cycle of plasmodium is completed in 2 host (vector is anopheles) {shown in diagram}

Amoebiasis/ amoebic dysentery (entamoeba histolytica)

Protozoan parasite in large intestine. Symptoms are constipation, abdominal pain, cramps, stools with mucous & blood clots. Housefly sit on faecus of infected person & spreads it.

Ascariasis (ascaris/round worm helminth)

Intestinal parasite, symptoms are internal bleeding, muscular pain, fever, anemia, blockage of intestinal passage. Eggs ofparasite is released in fecus which infects soil & water & spreads via contaminated veggies,fruit & water

NEET 2013

Elephantiasis or filariasis (wucheria brancofti, w. Malayi)

NEET 2020

Filarial worm mainly causes inflammation of lymphatic vessel of lower limb or sometime genital organ are also affected causing gross deformities & transmitted through female mosquito vector.

NEET 2018

Ringworms (genera microsporum, trichophyton, epidermophyton)

Symptoms are dry scaly lesions on skin,nails,scalp. Which are accompanied by itching. Heat,moisture support fungi to grow hence also grows in skin folds (groin or b/w toes). Acquired by using infected towel,cloth, comb or soil.

Personal hygiene & public hygiene (proper disposal and disinfecting of water reservoir) should be maintained to be protected from these diseases like typhoid, amoebiasis, ascariasis. For airborne diseases (pneumonia,cold) contact with infected ones should be maintained & for malaria,filariasis we need to control or eliminate vector & their breeding places. Dengue and chikungunya is supported by vector Aedes mosquito. Proper vaccination should be provided to be prevented from these disease.

IMMUNITY

Ability to fight disease causing organisms & is of 2 types innate and acquired.

Innate immunity

Provides different barriers to entry of foreign agents by physiological barrier (skin, mucous), physiological barriers (acid,saliva,tears), cellular barriers (pmnl neutrophil, monocyte & macrophages phagocytose), cytokine barriers (interferon secretion)

Acquired immunity

It is characterised by memory. Secondary response is anamnestic (powerful). Taken by B & T lymphocytes. T help B to produce antibodies.
Antibody have 4 poly peptide chain H2L2 AND they are of diff types like IgG,IgA,IgM,IgE,IgD.
Antibodies found in blood is humoral immune system. Cell mediated immunity is mediated by T lymphocytes & is responsible for graft rejection.

NEET 2019

Active immunity

Antibodies are produced in host against antigens. Injecting microbes during vaccination induce active immunity.

eg polio, Hepatitis, DPT etc

(NEET 2016)

Passive immunity

Ready made antibodies are directly given to protect the body from foreign agent. Yellowish fluid (colostrum) present in initial days of lactation has IgA to protect infant.

NEET 2016, 2020

Vaccination and immunisation

Based on memory of immune system. Vaccine generates memory -B & -T cells that recognise pathogen. In cases like tetanus, snake bites preformed antibodies/antitoxin are given (passive immunisation). rDNA technology has allowed the production of antigenic polypeptide (vaccine) of pathogen in bact. or yeast. Eg- hepatitis B vaccine from yeast.

Allergy

Response of immune system to certain antigen present in environment. The subst. Or that antigens to which response is given are called allergens (IgE type antibodies are produced) . Allergens can be mites in dust, pollen, animal dander. Symptoms can be sneezing, watery eyes, difficulty in breathing. Due to release of histamine/seratonin from mast cells. Use of antihistamine,adrenaline & steroids quickly reduce symptoms of allergy. Many children get allergy & asthma due to protected environment given in early life.

Auto immunity

Memory based acquired immunity based on ability to differentiate between self and nonself cells which is evolved in higher vertebrates. Higher vertebrates can distinguish hence dealt in many immunological experiments but sometimes due to genetic reason body attack self cells (auto immune disorder) eg- rheumatoid arthritis

NEET 2016 2018

Immune system in the body (lymphoid organs)

NEET 2017

Origin,maturation & proliferation of lymphocyte occur there. Primary lymphoid organ are bone marrow & thymus where immature lymphocytes differentiate into antigen sensitive lymphocytes & then it transfers to secondary lymphoid organ (spleen,lymph node, tonsil, peyers patches of small intestine, appendix) where interaction of lymphocyte to antigen occur which then proliferate to form effector cell. All blood cells including lymphocytes are formed in bone marrow. Thymus is lobed organ present near heart & beneath breast bone which reduces its size with age. Bone marrow & thymus provide micro environment for development of T lymphocytes. Spleen is large bean shaped organ mainly containing lymphocytes & phagocytes which act as filter of blood trapping blood borne microbes. Spleen is also a large reservoir of RBC. Lymph nodes are solid structure located at diff areas. They trap antigen which get into tissue fluid & which causes activation of lymphocyte & cause immune response. There is lymphoid tissue also located within the lining of major tracts called mucosa associated lymphoid tissue (MALT). It constitute about 50% of lymphoid tissue in human body.

AIDS (acquired immuno deficiency syndrome)

NEET 2016

Not a congenital disease. Syndrome means a group of symptoms. AIDS was first reported in 1981 & in last 25 years killed 25 million people. It is caused by HIV (human immuno deficiency virus) i.e. a group of viruses called retrovirus. Retrovirus have an envelope enclosing RNA genome. Transmission is due to sexual contact,transfusions,infected needle,infected mother to child. Time lag b/w infection and symptoms can be frim few month to 5-10 years. Enzyme linked immuno sorbent assay (ELISA) is used to test for aids. It can be partially treated by anti retroviral drug that increase life span. Prevention of aids :- NACO (national aids control organisation) teaches people about aids. Dispensable needles,controlling drug abuse, safe sex, are some preventive measures. (Note:- infected cell can survive while viruses are being replicated & released.

CANCER

AIPMT 2012

NEET 2010

Major cause of death because more than 1 million people suffered from it in india. Cancerous cells loose contact inhibition & divide to form masses of cell called tumor. Tumors are of 2 types:-

BENIGN TUMOUR- remain confined at original location & cause less damage

MALIGNANT TUMOUR- mass of proliferating cells called neoplastic/tumour cells which damage normal tissue. They starve surrounding cells by competing for nutrients.

> Causes of cancer- may be physical,chemical or biological agent called carcinogens, ionisation radiation like X ray, γ- rays, non ionisation radiation like UV cause dna damage. For eg- Carcinogen (chemical) in tobacco causes lung cancer. Oncogenic viruses with viral oncogene causes cancer or normal cells having cellular oncogene (c-onc) or proto oncogenes get activated under certain condition & lead to oncogenic transformation of cells.

> Cancer detection & diagnosis- biopsy & histopathalogical studies of tissue,blood & bone marrow test for increasing cell count in case of leukaemia.. In biopsy suspected tissue is cut,stained & studied. Radiography(x rays), CT(computed tomography) & MRI (magnetic resource imaging). Antibodies against cancer specific antigens, techniques of molecular biology ti detect genes inherited with cancer,identification of genes, which predispose one cancer sk that people can learn.

> treatment of cancer- surgery, radiation therapy (tumour cells are irradiated lethally),immunotherapy,chemitherapeutic drugs side effect are hairloss & ansmia, patients are given biological response modifier eg- a-interferon which activates immune system & destroy tumour.

Drug and alcohol abuse

Commonly abused drugs are as follows:-

NEET 2018 2019

Opioids

Bind to opioid receptor in CNS & GIT. Heroin (commonly smack) is diacetyl morphine which is a white,odourless bitter crystalline compound & obtained by acetylation of morphine (extracted from poppy plant (papaver somniferum)). Taken by snorting & injection. Heroin is depressant i.e. slows down body function.

Cannabinoids

Group of chemicals interact with cannabinoid receptors in brain which are obtained from inflorescence of cannabis sativa. Flower top, leaves & resin of cannabis is used in various combination to produce marijuana, hashish, charas, ganja. Generally taken by inhalation or oral ingestion & affect on cardiovascular system. They are also abused by some sports person.

Coca alkaloid / cocaine

Obtained from coca plant erythroxylem coca, native to south america which interferes with transport of neurotransmitter dopamine. Cocaine/coke/crack is snorted and has potent stimulating action on CNS producing sense of euphoria & increased energy and its excess causes hallucination. Atropa belladona & datura also have hallucinogenic property.

AIPMT 2014

Barbiturates amphetamines and benzodiazepines are used ti treat depression, insomnia & mental illness. Morphine is sedative & painkiller (advised after surgery). Some hallucinating plant, fruit seed have been used in religious & rituals. When these are taken other than medicinal use then it becomes drug abuse. Smoking paves way to hard drugs. Tobacco has been used by humans since 400 years. Tobacco contains nicotine (alkaloid) which stimulates releasing of adrenaline or nor adrenaline hence increases heartbeat/blood pressure. Smoking leads to cancer of lung, urinary bladder, throat, bronchitis,emphysema, coronary heart disease, gastric ulcer, etc. Tobacco chewinh leads ti oral cancer & smoking increases CO in blood.

Adolescence & drug abuse

Adolescence means both period and process and adolescence is a vulnerable phase. First it is due to excitement or curiosity but then it is to escape from problems.

Addiction & dependence

Addiction is psychological attachment to certain effects such as euphoria & a temporary feeling of well being associated with drugs & alcohol. Receptor present in body increase their tolerance level hence respond only to higher doses. Withdrawal syndrome:- dependence, unpleasant & characterised by anxiety, shakiness, nausea, sweating.

Effects of drug/ alcohol abuse

AIPMT 2012

Main effects are reckless behaviour, vandalism & violence. Excessive doses can lead to coma or death due to respiratory failure, cerebral haemorrhage or heart failure. Drug can make one thief and can drop its academic performance. Intravenous drugs may lead to AIDS & Hepatitis B by infected needle. Excessive abuse leads to damage to NS & liver (cirrhosis) drug abuse during pregnancy can adversely affect foetus. Sports person use narcotic analgesics, anabolic steroids, diuretics to increase muscle strength, bulk, aggressiveness & athletic performance.

SIDE EFFECTS IN FEMALE-

masculinisation, aggressiveness, mood swings, depression, abnormal menstrual cycle, enlargement of clitoris.

SIDE EFFECTS IN MALE-

Acne,aggressive, mood swings, depression, reduction of size of testicles, less sperm count, kidney, liver dysfunction, breast enlarge, baldness , enlargement of prostate gland.

It may also lead stunted growth in adolescents.

Prevention and control

Parenting is essential.

Some measures of prevention can be:-

> avoid undue peer pressure
> education and counselling (mentoring)
> seeking help from parents and peers
> looking for danger signs
> seeking professional & medical health

NCERT Diagrams for reference

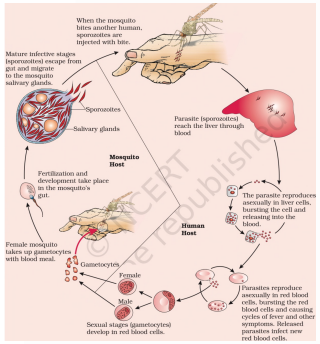


Figure 8.2 Diagram showing inflammation in one of the lower limbs due to elephantiasis

Figure 8.3 Diagram showing ringworm affected area of the skin

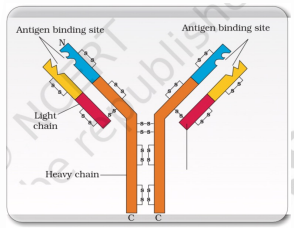


Figure 8.4 Structure of an antibody molecule

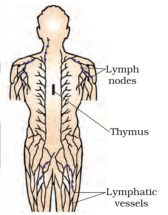


Figure 8.5 Diagrammatic representation of Lymph nodes

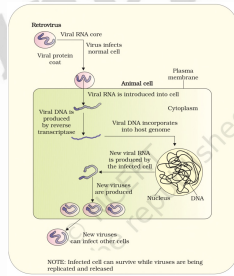


Figure 8.6 Replication of retrovirus

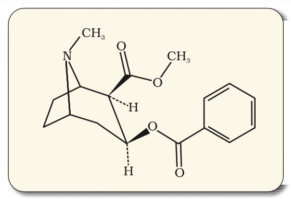


Figure 8.7 Chemical structure of Morphine

Figure 8.8 Opium poppy

Figure 8.11 Flowering branch of *Datura*

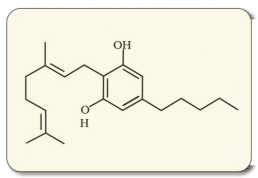


Figure 8.9 Skeletal structure of cannabinoid molecule

Figure 8.10 Leaves of *Cannabis sativa*

Strategies for enhancement in food production

Biological techniques are very useful in raising food production.
Needed for increasing population.

Animal husbandry

Art of agricultural practice of breeding & raising livestock like buffaloes, pigs, horses, camels, etc. which are useful to humans. I.e. poultry & fisheries. Fisheries- rearing, catching & selling of fish molluscs (shell fish) & crustaceans (prawns & crabs).
More than 70% livestock population is in india & china but contribution to the world farm produce js only 25% i.e productivity per unit is very low.

Management of farm & farm animals

I) Dairy farm management- management of milk giving animals for human consumption which involves systems to produce greater yield & more quality which depends ion the good breed (disease resistant) , hygiene, quality fodder, climate. Ensuring these measures would require regular inspections.
II) Poultry farm management- include class of domesticated foul (birds like chicken duck, turkey, geese) for food or eggs. Poultry refers to meat of birds. Require disease free good breed and hygiene.

Animal breeding

Important aspect of animal husbandry and it means raising quality of produce.
BREED:- group of animals similar in characters like appearance, features, size, configuration.

INBREEDING:- breeding b/w animals of same breed for 4-6 generations only superior male mates with superior female & progeny is identified for future mating. Eg- in cattle superior female is cow/buffalo cause give more milk per lactation & superior male is bull cause gives more superior progeny.
Inbreeding increases homozygosity i.e. obtaining more pure lines hence it is necessary if we want to evolve a pure line in any animal. Helps in accumulation of superior genes & eliminating less desirable genes. Hence increases productivity of inbred population by selecting at each step.
Continuously close inbreeding reduces fertility & productivity which is called inbreeding depression. And to overcome this selected animals of the breeding population are mated with unrelated of superior animals of same breed.

OUTBREEDING:- may be mating b/w animals of same breed with or different ancestors for 4-6 generations (outcrossing) or b/w different breeds (outbreeding) or different species (interspecific hybridisation).

OUTCROSSING:- no common ancestor on either side if pedigree & the offspring obtained is called outcross. It is very efficient for averagely producing animals & overcome inbreeding depression.

AIPMT 2015

CROSSBREEDING- breed b/w superior male with sup. female of another breed & progeny may be used for commercial production or subjected to inbreeding & selection to develops more stable & superior breeds. Eg- hisardale is new breed of sheep developed in punjab by crossing bikaneri ewes and marino rams.

NEET 2020

INTERSPECIFIC HYBRIDISATION:- parents are of 2 different related spercies & progeny may be of considerable economic value. Eg- mule.

CONTROLLED BREEDING EXPERIMENTS:- carried out using artificial insemination in which semen from male is transferred to female or frozen & kept for later. It helps to overcome many problems of normal matings. Success rate of crossing male & female is fairly low hence other means like multiple ovulation Embryo transfer technology (MOET) are used. Cow is fed with FSH to increase follicular maturation & super ovulation. Instead of 1 egg 6-8 eggs are released & is mated with an elite bull or artificially inseminated. Fertilised egg at 8-32 celled stage they are recovered non surgically & sent to surrogate mothers. Genetic mother is available again for super ovulation.
Eg- cattle,sheep,rabbit,buffaloes,mares for obtaining high milk yielding breeds of females & high quality (lean meat with less lipid) meat yielding bulls, which increase herd size in short time.

Bee- Keeping

Maintenance of hive for production of honey. Has been an age old cottage industry.
Honey beside having nutritional value but is also useful in making medicine & beside honey. Beeswax is also produced by bees which is used in cosmetics & polishes of various kinds. Mostly abis indica is reared.
-> it can be done at areas with sufficient bee pastures like wild shrubs, fruit orchard & cultivated crops (since bees are pollinators of sunflower, brassica, apple, pear hence they also help in pollination & hence beneficial in both ways)
-> beehives are kept in verandah or roof & this is not labour intensive.
Successful bee keeping involves:-
1) knowledge of nature & habit of bees
2) selection of suitable location for keeping hives
3) catching & hiving of swarm (group of bees)
4) management of beehives during different seasons
5) handling & collection of honey & of beeswax

Fisheries

Catching processing & selling of fish, shellfish (aqualife)
Edible aquatic animals- prawns, crab, lobster, edible oyster.
Freshwater fish- catala,rohu, common carp.
Marine fishes- hilsa,sardines, mackerel, pomfrets.
Provides income & employment to fisherman & farmers in costal region. Through aquaculture & pisciculture production in both fresh & marine water is increased. Introduction of blue r evolution.

Plant breeding

Green revolution lead the high yield & dependent on plant breeding techniques for development of high yield & disease resistant varieties in wheat,rice,maize. Evidence of plant breeding dates to 9000-11000 yr ago. Today all major food crops are derived from domesticated variety. Classical plant breeding involves crossing/hybridisation of pure lines followed by artificial selection to Produce plants with desirable traits. Now it is done by using molecular genetic tools. Desired traits- increased tolerance to environmental stresses (salinity,extreme temp., drought) resistance to pathogens & tolerance to insect pests. Plant breeding programmes are done in government institutions, commercial companies.

AIPMT 2012

PLANT BREEDING

MAIN STEPS IN BREEDING A NEW GENETIC VARIETY OF CROP-

1) **COLLECTION OF VARIABILITY**- genetic variability is root of breeding program. Collection & preservation of fluid varieties, species, relatives of the cultivated plant is necessary for exploitation of natural genes & they are only possible for pre existing genetic variability. The entire collection of plants/seeds having all diverse alleles for all genes in a given crop is called germ plasm collection. → NEET 2013

2) **EVALUATION & SELECTION OF PARENTS**- the selected plants are multiplied & used in hybridisation. Purelines are created whereas desirable & possible.

3) **CROSS HYBRIDISATION AMONG THE SELECTED PLANTS**- it is very tedious & time consuming cause pollen from 1 is to be dropped on stigma of 2 parent & there is no guarantee that hybrid do combine desirable character. Only very few are successful.

4) **SELECTION & TESTING OF SUPERIOR RECOMBINANTS**- careful scientific evaluation of progeny very often more than 1 superior progeny may available which are self pollinated for several generation till they reach homozygosity so the character will not segregate in progeny.

5) **TESTING, RELEASE & COMMERCIALISATION OF NEW CULTIVATORS**- newly selected lines are evaluated for their yield by growing in research field. Under ideal fertiliser, irrigation & is followed by growing in farmers field for 3 season at several location in country for different agroclimatic zone. The material is evaluated in comparison to the best available local crop cultivator- a check or reference cultivator.

NEET 2016

Agriculture accounts 33% GDP of india & employs 62% of population.

After independence, in mid 1960s, HYV were developed by plant breeding techniques which increased food production & this phase is called green revolution.

WHEAT & RICE- from 1960 to 2000 wheat production 11M tonnes to 75 M tonnes & rice production 35M tonnes to 89.5 M tonnes. Due to development of semidwarf varieties of wheat & rice & was developed by nobel laureate norman E. borlaug at international centre for wheat & maize improvement (mexico). In 1963 sonalika & kalyan sona varieties were introduced in india. Semidwarf rice were derived from IR-8 (developed at international rice research institute [IRRI] , Philippines) & taichung native-1 (from Taiwan) & were introducedin 1966. Later better yielding semi-dwarf varieties jaya & ratna were developed in india.

AIPMT 2011

SUGARCANE- saccharum barberi (grown in north + less sugar content) was crossed with saccharrum offinicinarum (tropical canes/grown in south + cannot be grown in north + high sugar content) to get hybrid.

MILLETS- eg- hybrid maize, jowar, bajra, are made in india. This hybridisation helps seeds to resist water stress.

Plant breeding for disease resistance

Crops are mainly affected by pathogens especially in tropical climates which makes several loss in crop. This helps in reducing use of fungicides, bacteriocides. Before breeding, the causative organism & the mode of transmission need to be studied.

FUNGI CAUSES RUST - eg- brown rust of wheat, red rot of sugarcane & late blight off potato; BACTERIAL CAUSES- black rot of crucifers & BY VIRUS- tobacco mosaic, turnip mosaic.

Methods of breeding for disease resistance

Can be done by conventional breeding techniques (described earlier) or mutation breeding the former include- screening germ plasm for resistance sources, hybridisation, selection & evaluation of hybrids, testing, release of variety.

The presence of no. Of disease of resistant genes in relatives is very low hence first by mutation that genes may be formed & then can be used inbreeding . Other methods are selection amongst somaclomal variants & genetic engineering.

MUTATION BREEDING- performed by chemicals or Y-radiations & selection. In mung bean, resistance to yellow mosaic virus & powdery mildew were induced by mutation. Some wild relatives have disease resistant genes but their yield is very low hence breeding comes into effect to produce hybrid. Eg- resistance to yellow mosaic in bhindi (abelmischus ascukantus) was transferred from a wild species & a new variety was formed called prarbhani kanti.

Plant breeding for developing resistance to insect pests

Resistance is provided by morphological, biochemical & physiolocharacters.

Eg- hairy leaves resists jassids in cotton, cereal leaf in wheat. In wheat solid stem lead to non-preference by the stem sawfly & smooth leaved & nectar less cotton varieties does not attract bollworms. High aspartic acid, low nitrogen & sugar in maize resist to maize stem borers. The breeding method is same as earlier.

SINGLE CELL PROTEIN (SCP)

Alt. source of proteins for animal & human nutrition.

Rate of production is less than rate of growing population. The shift of meat from grain also creates more demand of cereal as 3-10 kg cereal produce 1kg meat.

More than 25% of population suffers from hunger and malnutrition.

Microbes may be grown on an industrial scaleas a source of good protein. Eg- BGA like spirulina can grow on waste water frim potato processing plants (containing starch), straw, molassus, animal manuure, sewage to produce food rich food rich in protein, mineral, fat, carbohydrates, vitamin and it akso reduces population.

Bacteria like methylophilus methylotropus (increase rate of biomass production & growth) produce 25 tonnes of protein. Edible fungus (mushrooms) also help in this.

Plant breeding for improved food quality

840M people doesn't get proper food, 3B people are micronutrient sufferer, and also suffer from protein, vitamin deficiency (hidden hunger) cause diets lacks Fe, VitA. I, Zn (micronutrients) which reduce life span.

BIOFORTIFICATION:- breeding fir improved quality of nutrition with objectives/motives to improve protein quality/content, oil content/quality, vitamin content, micro-nutrient & mineral content. } AIPMT 2010

Things performed after 2000-

1) new maize hybrid having double the amount of amino acids, lysine, tryphtophan with comparison to older maize hybrid.

2) altlas 66(wheat variety)- used in high protein donor for improving cultivated wheat.

3) An Fe-fortified rice variety having 5 times than normal variety was developed.

Indian agricultural research institute (new delhi) developed-

Vit A riched carrots, spinach, pumpkin; vit C rich bitter gourd, bathua, mustard, tomato; Fe rich & Ca rich spinach , bathua; protein rich beans (broad,lablab, french, garden peas)

Tissue culture

> Found in 1950 because breeding was slow.
> any part of plant (explant) can regenerate whole plant when grown in test tube, under sterile condition & special nutrient mediator. This capacity is known as totipotency.
Nutrient media:- carbon source (sucrose) + inorganic salt + vit + amino acid + auxin + cytokinin
By this thousands of plant can be produced which js called micro propagation & each plant is genetically similar i.e. somaclomes to the parent. Eg- tomato, banana, apple.
> it can also be used to recover healthy plant from diseased plant if it is infected the meristem is free of virus hence it can be used jn tissue culture. Eg sugarcane, banana, apple
SOMATIC HYBRIDISATION:- if cell wall of isolated cell is digested then is able to isolate named protoplast (surrounded by plasma memb.) now the isolated naked protoplasts of 2 different varieties can be fused to get hybrid protoplasm.
These hybrids were known as somatic hybrids & process was known as somatic hybridisation. Eg- pomato (not commercially useful)

↓

NEET 2013

NCERT diagrams for reference

(a)

(b)

Figure 9.1 Improved breed of cattle and chickens (a) Jersey (b) Leghorn

Figure 9.2 Mule

(a) (b)

(c)

Figure 9.3 Some Indian hybrid crops: (a) Maize; (b) Wheat; (c) Garden peas

Table 9.1

Crop	Variety	Resistance to diseases
Wheat	*Himgiri*	*Leaf and stripe rust, hill bunt*
Brassica	*Pusa swarnim (Karan rai)*	*White rust*
Cauliflower	*Pusa Shubhra, Pusa Snowball K-1*	*Black rot and Curl blight black rot*
Cowpea	*Pusa Komal*	*Bacterial blight*
Chilli	*Pusa Sadabahar*	*Chilly mosaic virus, Tobacco mosaic virus and Leaf curl*

Table 9.2

Crop	Variety	Insect Pests
Brassica (rapeseed mustard)	*Pusa Gaurav*	*Aphids*
Flat bean	*Pusa Sem 2, Pusa Sem 3*	*Jassids, aphids and fruit borer*
Okra (Bhindi)	*Pusa Sawani Pusa A-4*	*Shoot and Fruit borer*

Microbes in human welfare

Microbes are also found in extreme environment & are diverse protozoan, bact., fungi, microscopic virus, prions.

Microbes in household products

- Lactic acid bacteria or lactobacillus produce acids that partially digest the milk protein & its small amount of curd acts as inoculum/ starter. This increases vit B12 & checks disease causing microbe in our stomach. — NEET 2018
- Dough of bread is fermented by bakers yeast (saccharomyces cervisiae) — AIPMT 2004, NEET 2018
- Toddy a traditional drink of south is fermented by fermenting sap from palms.
- Microbes also ferment fish, bamboo shoot & soyabean for food. Cheese are fermented since long years back & different types of cheese is found on the basis of microbes used. Eg- large holes in swiss cheese is due to more CO_2 by propionibacterium sharmanii. 'Roquefort cheese' is ripened by fungi which gives flavour.

Microbes in industrial products

Production is taken in large vessel called fermentors.

- **FERMENTED BEVERAGES-** Brewers yeast ferments malted cereals & fruit juices to produce ethanol. Wine and beer are produced without distillation, while whisky, brandy & rum are produced by distillation of the fermented broth.
- **ANTIBIOTICS-** (Against life of disease causing microbes) its discovery was a serendipity when alexander flemming was working on staphylococci bact. But that bact. Was not able to grow on the unwashed plate cause the release of chemical from mould (penicillium notatum) & that chemical penicillin. Effective antibiotic was given by ernest chain & howard florey. This was used to cure wounded American soldier in WW2. Those 3 were given nobel prize in 1945. Antibiotics help for curing plague, whooping cough(kaali khasi), diptheria (gal ghotu), leprosy (kusht rog) which may kill millions of people. These were also obtained by microbes.
- **CHEMICALS,ENZYMES & OTHER BIOACTIVE MOLECULES-** Acid producers —> aspergillus niger fungi for citric acid, acetobacter aceti bact. For acetic acid, clostridium butylicum bact for butyric acid, lactobacillus bact for lactic acid. — NEET 19, 20
  Lipases used in detergents to clear oil stains, bottled juices are cleared by pectinases & proteases. Streptokinase (produced by the bacteria streptococcus & modified by genetic engineering) is used as clot buster for removing clots from blood vessels of patient undergone myocardial infarction leading to heart attack. — NEET 2016
  Cyclosporin A (bioactive molecule) produced by trichoderma polysporum fungus & used as immunosuppressive agent in organ transplantation. — NEET 2020
  Statins produced by yeast monascus perpureus is used as blood cholesterol lowering agent & it acts as completely inhibiting the enzyme responsible for synthesis of cholesterol. — NEET 19, 20

Microbes in sewage treatment

Before disposal sewage (municipal waste water) is treated in sewage treatment plants (STP) to make it less polluting & is done by heterotrophic bacteria naturally present in sewage which is carried out in 2 stage.

PRIMARY TREATMENT :– NEET 2017

Initially floating debris is removed by sequential filtration. → Grit is removed by sedimentation. All solid settle form primary sludge. → Primary sludge is supernatant part of the effluent → Effluent from primary settling tank is taken for secondary treatment.

SECONDARY TREATMENT :– BIOLOGICAL (AIPMT 2011)

Primary effluent is passed in aeration tank & is agitated mechanically & air is pumped in it. → Growth of aerobic microbes into floc (masses of bact. Associated with fungal filament) → Small amount of sludge is pumped back in aeration tank as inoculum & remaining is turned into anaerobic sludge digesters (tanks) → Anaerobic microbes digest the aerobic ones & release CH_4,HS,CO_2 which can form biogas as source of energy.

NEET 2020 — NEET 2019

Effluent from secondary treatment is sent into rivers. The ministry of environment & forests has initiated ganga action plan & yamuna action plan to make several plants & hence only treated sewage water is disposed in the river.

Microbes in production of biogas

The type of gas produced depends upon the microbes & organic substance utilised CH_4 gas is produced by methanogens (specifically methanobacterium) which feed on cellulosic material. These are found in anaerobic sludge or rumen of animals (digest cellulose) hence dung js also used for generation kf biogas/gobar gas. The plant consists of concrete tank (10-15 ft deep) in which slurry ja fed & cover which collects gases. The spent slurry may be used as manure. Biogas plants are more often in rural areas. This technology was developed in india mainly due to efforts of Indian agricultural research institute (IARI) & khadi and village industries commission (KVIC)

Microbes as biocontrol agents

Use of biological method for controlling pest & plant disease cause insecticides pollute environment.

BIOLOGICAL CONTROL OF PESTS & DISEASES- Requires natura predation rather than chemicals. Organic farmers believe that biodiversity furthers health i.e. mor landscape has more sustainable it is. Organic farmer uses system of check and balances in place of chemicals which kills both useful & harmful life forms. i.e. the hosts or the food containing creatures may also kill. One should be familiar with life forms that inhibit in field & their daily activity for perfect biocontrol which reduces dependency on chemicals

NEET 2013, 19

Bact. Bacillus thuringiensis (Bt) is available in sachets which are mixed with water and sprayed on brassicas & fruit trees which goes inside butterfly caterpillar & toxin released by them kills it. Scientists have also introduced BT toxin genes into plants so that it is resistant to caterpillar. Eg- Bt cotton.

Fungus trichoderma is effective in protecting plant from several pathogens.

BACULOVIRUSES- pathogens that attack insects and other arthropods whixh mainly belong to nuleopolyhedrovirus genus. These are excellent candidates for species specific, narrow spectrum insecticide application & have Zero effect on other organisms. It is specially desirable when benificial insects are being conserved to aid in an overall integrated pest management (IPM) Programme, or when ecologically sensitive area is treated.

Microbes as biofertilisers

To prevent pollution

Biofertilisers are organisms that enrich the nutrient quality of soil which may be bact. , fungi, BGA. Eg- rhizobium fixes N2 being symbiotically associated while azospirullum & azotobacter are free living.

Mainly glomus genus of fungi forms mycorrhiza which absorbs P from soil & gives it to plant & plant shows resistance to root borne pathogens, tolerance to salinity & drought.

AIPMT 2012

Many of cyanobacteria like Nostoc, anabena, oscillatoria fix atmospheric nitrogen. BGA adds fertility to soil. In paddy fields cynobacteria serve as important biofertilisers.

NEET 2017

NCERT diagrams for reference

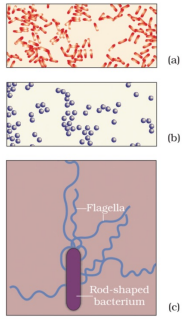


Figure10.1 Bacteria: (a) Rod-shaped, magnified 1500X; (b) Spherical shaped, magnified1500X; (c) A rod-shaped bacterium showing flagella, magnified 50,000X

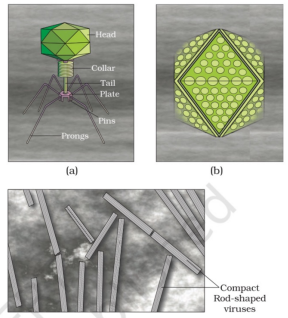


Figure 10.2 Viruses: (a) A bacteriophage; (b) Adenovirus which causes respiratory infections; (c) Rod-shaped Tobacco Mosaic Virus (TMV). Magnified about 1,00,000–1,50,000X

Figure 10.4 Fermentors

Figure 10.5 Fermentation Plant

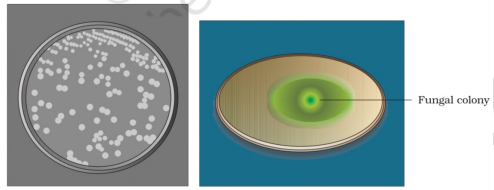


Figure 10.3 (a) Colonies of bacteria growing in a petri dish; (b) Fungal colony growing in a petri dish

Figure 10.6 Secondary treatment

Figure 10.7 An aerial view of a sewage plant

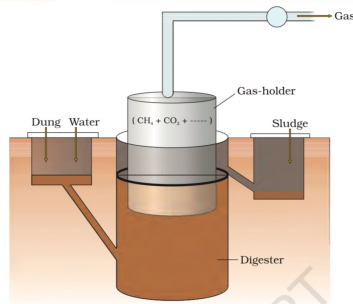


Figure 10.8 A typical biogas plant

Biotechnology and its applications

Biotechnology deals with industrial scale production of biopharmaceuticals & biologicals using genetically modified microbes, fungi, plants, animals.
3 critical research area of biotechnology -
1) providing best catalyst in form of improved organism / microbe or pure enzyme.
2) creating optimal condition through engineering for a catalyst to act.
3) downstream processing technology.

Biotechnological application in agriculture

THREE OPTIONS FOR INCREASING FOOD PRODUCTION-
1) agro-chemical based agriculture.
2) organic culture.
3) genetically engineered crop based agriculture.
Green revolution tripled the production but then also inadequate. Increased yields was partly due to improved crop variety but mainly cause of management propactices & agro- chemicals (expensive & harmful & also conventional breeding is not enough productive). Hence use of genetically modified crop was a solution.

Genetically modified organism (GMO)-

Whose genes have been altered by manipulation & it has made crops
1) more tolerance to abiotic stresses (cold,drought)
2) reduced reliance on chemical pesticides.
3) reduced post harvest loss
4) increases efficiency of mineral usage by plants (prevents early loss of fertility)
5) enhanced nutritional value.
Eg- GOLDEN RICE (rich in Vit A). Genetical modification has been used to create tailor made plants to supply alternative resources to industry. Eg- starch, fuels, pharmaceuticals.
Bt toxin produced by bacteria bacillus thuringiensis & when transferred to plants as Bt toxin gene, gives resistance to insect (Bio-pesticide). Eg- Bt cotton, Bt corn, rice, tomato, potato & soyabean.

Bt- cotton

Kill insects like lepidopterans (tobacco budworm, armyworm, coleopterans (beetles), dipterans (flies,mosquito). Bt bact. forms protein crystals during a phase which contain toxic insecticidal protein which exists as inactive protoxins. But as insect ingest it due to alkaline pH of gut which solubilise crystal & make them active to bind with surface of midgut epithelium & create pores cause swelling, lysis & death of insect. (Choice of gene depends on crop cause Bt toxin are insect group specific). The toxin is coded by a gene cryIAC named Cry. There are no. of them, for eg- protein encoded by cryIAC & cryIIAB control cotton bollworms that of cry IAB controls corn borer.

NEET 2019

Pest resistant plants-

NEET 2016

Nematodes mainly constitute parasites. A nematode meloidegyne icognitia infects the roots of tobacco plant & cause reduction in yield. To prevent this infestation, novel strategy was adopted based on RNA interference (RNAi). Which is used as defence mechanism & takes place in every eukaryotes & involves silencing of a specific mRNA due to a complementary dsRNA molecule that binds to & prevents translation of the mRNA (silencing) the source of this complementary RNA could be from an infection by viruses having RNA genomes or mobile genetic elements (transposons) that replicate via an RNA intermediate.

NEET 2019

Using agrobacterium vectors, nematode- specific genes were introduced into host plant which produced both sense & antisense RNA in host which are complimentary to each other. Formed a dsRNA that initiated RNAi (silenced mRNA of nematode) the sequence was that the parasite could not survive in a transgenic host expressing specific interfering RNA. The transgenic plant therefore got itself protected from the parasite. (Novel mechanism*)

Biotechnological application in medicine

The recombinant therapeutics do not induce unwanted immunological responses as is common in case of similar products isolated from non- human sources. At present, about 30 recombinant therapeutics have been approved for human use the world over. In india - 12 marketed now.

Genetically engineered insulin-

Insulin (for curing adult onset diabetes) can't be ingested orally cause it get digested cause it is protein. Earlier it was extracted from pancrease of slaughtered cattle & pig but causes allergy, reaction to foreign protein.

NEET 2016

Insulin consists of 2 short polypeptide chains (A & B) that are linked by disulphide bridges.

NEET 2020

In mammals, insulin is synthesised as pro hormone which contain extra stretch of C peptide (not found in mature). Main challenge for production of insulin using rDNA technology was getting in mature form.

NEET 2020

In 1983, Eli lilly (american company) prepared 2 DNA Sequence separately (corresponding A & B) & linked by disulphide bond, chains of human insulin & introduced in plasmid of E. coli to produce insulin chains.

Gene therapy-

It is an attempt to eliminate inborne hereditary disease i.e. a collection of methods which allows correction of gene defect in which genes (normal) are inserted in persons (defeated) cells/embryo which take over function of non functional gene.
First clinical gene therapy was given in 1990 to a 4 year old girl with adenosine deaminase (ADA) Deficiency cause its crucial for immune system to function & caused due to deletion of gene coding for ADA. In some children, can be cured by bone marrow transplant, in others treated by enzyme replacement therapy (functional ADA is given as injection). 1st step —> lymphocytes from blood of patient is grown in vitro & functional ADA, cDNA (using retroviral vector) is then introduced & then set up is returned to patient & since these are not immortal (cells) hence patient requires periodic infusion. If gene isolate from marrow cells producing ADA is introduced into cells at early embryonic stages, it could be a permanent cure.

NEET 2016

AIPMT 2009

Molecular diagnosis-

Early diagnosis & understanding pathophysiology is crucial. Conventional method (serum, urine test) are not early technique. Early diagnosis include rDNA Tech., PCR, ELISA (enzyme linked immuno sorbent assay). Presence of pathogen is detected when symptoms occur but at that time concentration increased. But it can be recognised in low conc. By PCR. It is used to detect HIV, mutation in gene in suspected cancer patients.
A ssDNA / ssRNA, Tagged with a radioactive molecule (probe) is allowed to hybridise to its complementary DNA in a clone of cells followed by deletion using autoradiography. The clone having mutated gene will hence not appear on the photographic film cause the probe will not have complementarity with mutated gene. Elisa is based on antigen-antibody interaction. Presence of antigen (protein, glycoprotein) /antibody means presence of pathogen.

Transgenic animals

They have had their DNA manipulated to possess & express an extra (foreign gene). Trangenic rats, rabbit, pig, sheep, cow, fish have been produced. Over 95% of all existing transgenic animals are mice. Reasons for modification:-

Normal physiology & development

Study of how genes are regulated, affect normal function, development. Eg- study of insulin like growth factor. Also stuying the result of introducing another gene that alters function of part. gene.

Study of disease

To study how genes contribute to the development of disease. Transgenic animals serve as models for human disease so investigation of new treatments made possible. Eg of diseases models exist today- cancer, cystic fibrosis, pheumatoid arthritis & alzheimers.

Biological products

Introduction of portion of DNA which encodes for product is used. Eg- human protein (α- 1- antitrypsin) used to treat emphysema & similarly for phenylketonuria (PKU) & cystic fibrosis. In 1997, first transgenic cow (rosie) produced human protein (human alpha lactalbumin) ruch milk (2-4gm per litre) & was nutritionally more balanced for babies than natural.

Vaccine safety

Transgenic mice/ monkey are developed for testing safety of vaccine.
Mice was used to test polio vaccine.

Chemical safety testing

Known as toxicity/safety testing & same as testing toxicity of drugs. They carry genes which make them more sensitive to toxic substance than non transgenic. They are then exposed to toxic substance & effects thus studied (allow us to obtain results in less time.

AIPMT 2003

Ethical issues

NEET 2018

Indian govt. has set up organisation such as GEAC (genetic engineering approval committee) which will make decisions regarding validity of GM research & safety of introducing GMO for public services.
There are many problems with patent granted for the same & growing public anger that certain companies are granted patents for products that have long been identified, used by farmers of specific region.

NEET 2018

200,000 varieties of rice in india (one of richest in world), 27 documented varieties of basmati are grown in india. Reference of basmati is found in ancient texts, folklore hence grown for centuries. In 1997, an american company got patent rights on basmati rice through the US patent and trademark office which allowed company to sell a new variety of basmati, in US, Abroad but derived from indian farmers varieties. Indian basmati was crossed with semidwarf varieties & claimed as an invention/novelty.

Patent extends to functional equivalents, implying that other people selling basmati rice could be restricted by patent. Several attempts have also been made to patent users products & processes based on indian traditional herbal medicine. Eg- turmeric, neem.

BIOPIRACY- use of bio-resources by multinational company without proper authorisation from the countries/people concerned without compensatory payment (happens cause most industrialised nations are rich financially but lack diversity & traditional knowledge & underdeveloped world is rich in biodiversity.

NEET 2018

Traditional knowledge related to bio resources can be exploited to develop modern applications and can also be used to save time, effort & expenditure during their commercialisation.

Some nations are developing laws to prevent such unauthorised exploitation.
The indian parliament has recently cleared the second amendment of the indian patents bill, that takes such issues into consideration, including patent terms emergency provisions & research & development initiative.

NCERT Diagrams for reference

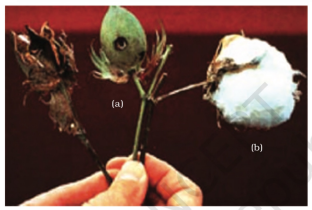


Figure 12.1 Cotton boll: (a) destroyed by bollworms; (b) a fully mature cotton boll

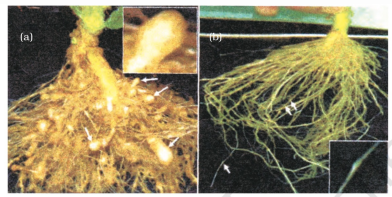


Figure 12.2 Host plant-generated dsRNA triggers protection against nematode infestation: (a) Roots of a typical control plants; (b) transgenic plant roots 5 days after deliberate infection of nematode but protected through novel mechanism.

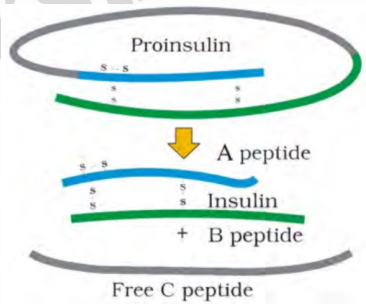


Figure 12.3 Maturation of pro-insulin into insulin (simplified)

Biotechnology: principles and processes

Biotechnology deals with techniques of using live organisms/enzymes producing products & processes useful to humans. Eg- in-vitro fertilisation, synthesising gene, producing DNA vaccine , correcting defective gene.

Definition by EFB (European federation of biotechnology) which includes traditional as well as modern molecular biotech- the integration of natural science & organism, cells, parts therof & molecular analogues for products & services.

Principles of biotechnology

2 core techniques that gave birth to modern biotechnology.

Genetic engineering

Altering chemistry of DNA & RNA to introduce these into host organisms & thus changes phenotype of host.

Traditional hybridisation technique (selection of plant and animal)- very often lead to inclusion & multiplication of undesirable genes along with desirable. The technique of genetic engineering (creation of recombinant DNA (rDNA), gene cloning, gene transfer) over comes this.

Bioprocess engineering

Maintenance of sterile (microbial free) condition in chemical engineering to enable growth of desired in large quantity for high production.

DNA do not replicate itself but chromosome does cause it have specific DNA sequence called ORIGIN OF REPLICATION (initiates replication) thus an alien DNA needs to be part of a chromosome & thus linked with origin of replication (ORI) & can replicate itself in the host organism which is termed as cloning.

First recombinant DNA (from salmonella typhimurium)

Cohen & boyer in 1972 isolated antibiotic resistant gene by cutting piece of DNA from other plasmid (autonomously replicating circular) via molecular scissors (restriction enzymes) & thus responsible for conferring antibiotic resistance. Its plasmid is used to link with desired DNA.

The cut piece of DNA then linked with plasmid DNA of salmonella typhimurium which act as vectors i.e. transfer piece of DNA into host body. Linking of gene took place via DMA ligase (join ends) & makes new plasmid in vitro known as rDNA & when transferred to E. coli (closely related to salmonella) then it could replicate using the new Host's DNA polymerase enzyme & produce cloning of antibiotic resistant gene.

Hence 3 steps of genetically modifying an organism-
1) identification of DNA with desirable genes.
2) Introduction of it in host
3) maintenance of it in host & transfer of DNA to its progeny.

TOOLS OF rDNA TECHNOLOGY

(I) Restriction enzymes — molecular Scissors NEET 2019

In 1963, 2 enzymes discovered which restricted bacteriophage growth in E. coli. One added methyl group while other cut DNA. Latter one called restriction endonuclease.
First restriction endonuclease was Hind II (Characterised 5 years later) it cut DNA at particular point of a specific sequence of 6 base pair (called recognition sequence for Hind II.) today we know 900 restriction enzymes from 230 strains of bacteria & each recognise different recognition sequences.

NAMING OF RESTRICTION ENZYMES-
First letter is genus, second 2 letters for species of cell from which it was isolated. Eg- EcoRI comes from E coli RY13 (R denotes name of strain from which it is derived & roman no. Indicating order in which enzymes were isolated from strain.
Restriction enzymes belongs to large class called nucleases (2 types endonuclease & exonuclease)
Exonuclease remove nucleotides from ends, endonuclease cut or remove at specific position.
AIPMT'15
Each restriction endonuclease functions by inspecting the length of a DNA sequence and then binds to DNA & cut each 2 strands in sugar phosphate backbone.
Each restriction endonuclease recognise recognises specific palindrome nucleotide sequence (same from either side eg- MALAYALAM).

Restriction enzymes cut DNA STRAND a little away from centre of palindrome sites but b/w 2 bases on opposite strands which leaves single stranded portion at end.
[Sticky ends over hanging stretches on each strand - named cause forms H bond with counter]
NEET 2016 2020
When cut by same restriction enzyme, DNA fragments have same kind of sticky ends & can be joined by DNA Ligase. & unless one cuts vector and source DNA with same restriction enzyme, recombinant vector cannot be made.
NEET 2016, 2020

SEPARATION & ISOLATION OF DNA FRAGMENTS (produced via endonuclease)-
By gel electrophoresis cause DNA Fragments are negatively charged & moves towards anode in application of electric field through matrix or medium (most common is agarose which is natural polymer from sea weeds) they get separated according size through sieving effect providedby agarose gel.
(Smaller the fragment farther it moves). Bright orange coloured DNA Fragments!. The fragments are visible after staining from ethidium bromide followed by exposure of UV rays cause pure DNA is visible light.
Segments are cut from gel & extracted from gel piece (step called elution) & they are used in recombinant DNA by joining with cloning vectors. EcoRI cuts DNA b/w bases G & A if the sequence GAATTC is present in DNA.

(II) Cloning vectors

Bacteriophages because of high no. Per cell have high copy no. Of their genome within bacteria cells. Some plasmid have 1 or 2 copy per cell & some have 15-100 copy per cell. We can multiply no. Equal to copy no. Of plasmid or bacteriophage by linking it to DNA. Features required to facilitate cloning into a vector are:

ORIGIN OF REPLICATION-
Sequence from where replication starts & if one wants many copies of target DNA it should be cloned in vector where origin support high no. Copy. NEET 2020

SELECTABLE MARKER

Helps in identifying & eliminating non transformants & selectively permitting growth of transformants [transformation - piece of DNA in host bacteria]

AIPMT 2012-

genes encoding resistance to antibiotics such as ampicillin, chloramphenicol, tetracycline or kanamycin, etc. are useful selectable markers for E. coli. Normal E. coli do not carry resistance against these antibiotics.

CLONING SITES

To link alien DNA, vector needs to have very few (single) recognition sites for commonly used restriction enzyme cause many leads to many fragments & thus complicates gene cloning. Ligation of alien DNA is carried out at a restriction site present in one of the 2 antibiotic resistance genes.

Eg- We can ligate alien DNA at BamHI site of tetracycline resistance gene in vector pBR322. The recombinant plasmids will loose tetracycline resistance due to insertion of foreign DNA but can still be selected out from non-recombinant ones by plating the transformant on tetracycline containing medium. The transformants on ampicillin containing medium are then transferred to tetracycline medium. There recombinant will grow in ampicillin containing medium but not on later. But non recombinants will grow on the medium containing both the antibiotics. In this case, one antibiotic resistance gene helps in selecting transformants whereas the other antibiotic resistance gene gets inactivated due to insertion of alien DNA & helps in selection of recombinants which requires simultaneous plating on two plates having different antibiotics. Thus alternative selectable markers have been developed which differentiate recombinants from non recombinants on the basis of their ability to produce a colour in the presence of chromogenic substrate.

In this a recombinant DNA is inserted in coding sequence of enzyme β- galactosidase which results into inactivation of gene for synthesis of this enzyme & called INSERTIONAL INACTIVATION.

Presence of chromogenic substance -> blue colour -> plasmid has no insert (presence of insert -> insertional inactivation of B- galactosidase -> no colour —> recombinant colonies).

NEET 2013, 15

VECTORS FOR CLONING GENES IN PLANTS & ANIMALS

Agrobacterium tumifaciens a pathogen of several dicot plants is able to deliver a piece of DNA known as T-DNA to transform normal plant cell into tumor & direct to produce chemicals required by pathogen but these has been modified into a cloning vector & is not pathogenic but use mechanism to deliver gene of our interest into a variety of plants. Its Ti plasmid is used as cloning vector.

Similarly retrovirus in animals have ability to transform normal cells into cancerous cells but now they have also been disarmed and are now used to deliver desirable genes in animal cells.

Once a gene/DNA fragment has been ligated into suitable vector it is transferred into bacteria, plant, animal host (where it multiplies).

(II) Cloning vectors (for transformation with rDNA)

DNA is hydrophilic (can't enter cell membrane) hence for it bacteria cell must be competent & is done by treating cell with divalent cation (Ca^{2+}) —> increases efficiency with which DNA enters through pores in its cell wall.

rDNA thus can be forced by incubating cells with rDNA on ice followed by placing them briefly at 42°C (heat shock) and then putting them back on ice. This enables bacteria to take up rDNA.

MICRO-INJECTION (another method)- rDNA directly injected into nucleus of animal cell

BIOLISTICS/GENE GUN (For plant cells)- plants cells are bombarded with high velocity micro-particles of gold, tungsten coated with DNA.

DISARMED PATHOGEN VECTOR- allowed to infect a cell. (transfer rDNA in host).

PROCESSES OF RECOMBINANT DNA TECHNOLOGY

(I) isolation of the genetic material (DNA)

Many impurities are found in DNA (RNA, Protein, polysaccharides, lipids) hence to make it pure cell is treated with lysozyme (bact.), cellulase(plant cells), chitinase(fungus), ribonuclease (for RNA), protease (for protein).

NEET 2013, 19

Pure DNA precipitates after addition of chilled ethanol (fine threads in suspension) (genes are located on long DNA interwined with protein such as histones)

(II) cutting of DNA at specific locations

Restriction enzymes digestion are performed by incubating pure DNA with restriction at optimal condition.

Electrophoresis is employed to check progression of restriction enzyme digestion & process is repeated with vector DNA also.

Cut out gene of interest + cut vector —> mixed + ligase is added —> rDNA is formed.

NEET 2017, 2019

(III) amplification of gene of interest using PCR (polymerase chain reaction)

In PCR Many copies of gene/ DNA of interest are synthesised in vitro using sets of primers. (Small chemically synthesised oligo nucleotides that are complimentary to regions of DNA) & DNA Polymerase which extends primers using nucleotides provided in reaction & genomic DNA as template.

Repeated replication—> segment of DNA can be amplified to billion times i.e. 1b copies & is achieved by use of thermostable DNA Polymerase (isolated from bacteria thermus aquaticus) & active for high temperature denaturation of ds DNA.

AIPMT 2012, 16, 20

Amplified fragment can now be used to ligate with a vector for further cloning.

(IV) insertion of rDNA into host cell

(Need to make cell competent)
If rDNA bears gene for resistance to antibiotic (eg- ampicillin) is transferred into E. coli, the host becomes transformed into ampicillin resistant cells. On spreading them at agar plate containing ampicillin then only transformants lived rest die. Hence one is able to select transformed cell in presence of ampicillin. Hence ampicillin resistance gene here is called selectable marker.

(V) obtaining foreign gene product

In almost all recombinant technology, ultimate aim is to get desirable protein hence there is need for rDNA to be expressed. (Foreign gene gets expressed under appropriate conditions).
After cloning & having optimum condition, large production is needed. If any protein encoding gene is expressed in a heterologous host. It is called a recombinant protein. Cells may be cultured in lab but high yields multiplies in a continuous culture system where in the used medium is drained out from one side while fresh medium is added from other side to maintain the cells in their physiologically most active log/exponential phase.

NEET 2019

BIOREACTORS- used for large production where 100-1000L vol of culture can be prepared. These are vessels in which raw materials are biologically converted into specific products using microbial plant, animal or human cells & provide optimal condition.

AIIMS 2010

Stirring type bioreactor —> most common which is cylindrical with curved base for mixing. Stirrer facilitated even mixing of O2 availability throughout reactor, it have an agitator system, O2 delivery system, foam control system, temp. Control system, pH control system & sampling ports so that small volumes of culture can be withdrawn periodically.

NEET 2016

(VI) downstream processing

After completion of the biosynthetic stage, separation & purification are done before marketing. → NEET 2017
The product has to be formulated with suitable preservatives & need to undergo thorough clinical trials as in case of drugs.
Strict quality control testing for each product is also required.
The downstream processing and quality control testing vary from product to product.

NCERT Diagrams for reference

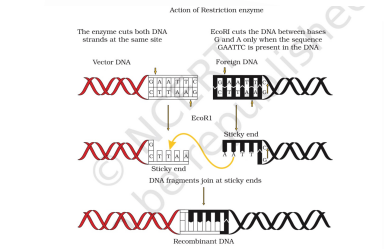


Figure 11.1 Steps in formation of recombinant DNA by action of restriction endonuclease enzyme – EcoRI

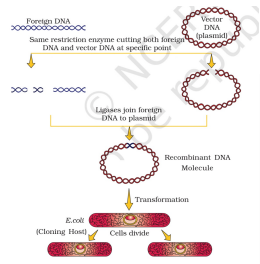


Figure 11.2 Diagrammatic representation of recombinant DNA technology

5′ —— GAATTC —— 3′
3′ —— CTTAAG —— 5′

Sequence identified by EcoRI

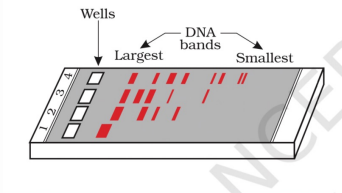


Figure 11.3 A typical agarose gel electrophoresis showing migration of undigested (lane 1) and digested set of DNA fragments (lane 2 to 4)

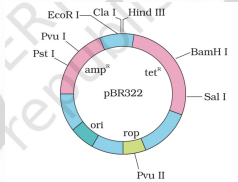


Figure 11.4 *E. coli* cloning vector pBR322 showing restriction sites (*Hind* III, *Eco*R I, *Bam*H I, *Sal* I, *Pvu* II, *Pst* I, *Cla* I), ori and antibiotic resistance genes (amp^R and tet^R), rop codes for the proteins involved in the replication of the plasmid.

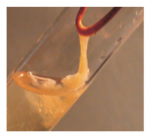


Figure 11.5 DNA that separates out can be removed by spooling

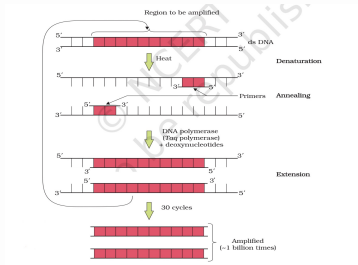


Figure 11.6 Polymerase chain reaction (PCR) : Each cycle has three steps: (i) Denaturation (ii) Primer annealing; and (iii) Extension of primers

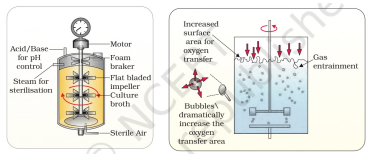


Figure 11.7 (a) Simple stirred-tank bioreactor; (b) Sparged stirred-tank bioreactor through which sterile air bubbles are sparged

Organisms & populations

ORGANISM & ITS ENVIRONMENT-
Ecology at organismic level is essentially physiological ecology which tells us about the adaptation. The variation in season due to motion of sun & precipitation causes formation of different biomes such as desert, rain forest & tundra and local/regional variations in biome lead to various habitat.
What causes variation in habitat:
1) Abiotic factors- temp., water, light, soil
2) Biotic factors- pathogens, parasite, predators, competitors of organisms.
Niche is the functional role of organism in system, range of conditions it can control or resources it utilise.

Major abiotic factors

NEET 2015

Temperature

(Most imp factor) temp. Decrease as receeding away from equator. It affects kinetics of enzymes in the metabolic reaction.
Eurythermal- can survive in variety of temp. AMU 2012
Stenothermal- restricted to a narrow range of temp.

Water

For aquatic org. Ph of water become important.
Salinity- conc. Of salt measured in parts per thousand
Inland water- <5
Sea water- 30-35
Hypersaline lagoon- >100
Euryhaline- tolerate wide range of salinity.
Stenohaline- tolerate narrow range of salinity.
Many fresh water fishes cannot live in sea due to osmotic problem.

Light

For photosynthesis & flowering (photoperiodism) in plants. Some plants require low light because they are adapted to canopied sheads. In animals they use diurnal & seasonal variation in light intensity & duration as cues for timing their foraging, reproductive & migrating activity.

Soil

Quality of different soil varies upon climate, weathering process, transported or sedimentary, how soil deviation occurs. Soil comp., grain size determine water holding capacity. PH, mineral richness, topography determine vegetation. Similarly in aqua-sphere the sediment characteristics often determine the type of benthic animals that can thrive there.

NEET 2013

Major abiotic factors

Regulate

AIPMT 2010

Some org. Maintain constant body temp. & osmoregulation(by physiological & behavioural changes) . Eg- birds, mammals, few invertebrates. In hot climate we sweat which causes cooling & in cold we shiver. Plants don't have such mechanism.

Conform

They cannot keep their internal environment constant. 99% of all are conformers for eg- in aquatic animals, their temp. & osmoregulation depends upon surrounding environment. Eg- shrews, hummingbirds. They have not evolved because of high energy requirements.
Partial regulators regulate but only over a limited range but then they conform.

Migrate

Temporary avoiding stress conditions to hospitality. Eg- in winters keolado national park (bharatpur) in rajasthan host thousands of siberian crane & migratory birds.

NEET 2014

Suspend

Bact., fungi & lower plants form spores to handle unfavourable condition. Higher plants form seeds which enter dormancy. Animals like bear go hibernation & fish, snail enter aestivation and some zooplankton enter diopause, a stage of suspended development.

Adaptations

Attribute of the organism (morphological, physiological, behavioural) eg- migration. Many adaptations are evolved and genetically fixed.

ADAPTATION OF KANGAROO RAT IN NORTH AMERICAN DESERTS- fulfil water needs by fat oxidation in which H2O is by product, concentrate urine.

AIPMT 2008

ADAPTATIONS IN DESERT PLANTS-Thick cuticle, sunken stomata, CAM photosynthetic pathway which enables stomata open at night. Eg- opuntia have no leaves (thorn) & photosynthesis is done by flattened stem.

ALLENS RULE- mammals of colder climate have short ear & limbs to minimise heat loss. Seals have fat layer called blubber that acts as insulator.

Symptoms of altitude sickness are nausea fatigue and heart palpitations which is overcome by adapting i.e. more Hb count, increase in RBC Count, decreased affinity of Hb, increased breathing rate. AIPMT 2012

Another example is of desert lizard which bask in sun to maintain body temperature i.e. a behavioural adaptation. Some organism may also burry under ground to escape the surface heat. Some fishes thrive in antarctic water with temp. Below 0°C. AIPMT 2011

Populations

Population attributes

AIPMT 2007

Group of individual resulting from asexual reproduction is also population for ecology. It is the population that natural selection operator to evolve the desired traits. Population is a group of people that compete for similar resources & potentially interbreed.

A population have attributes but organism doesn't. An individual may have birth or death but population has birth rate & death rate refer to per capita births & deaths i.e. expressed as increase or decrease in no.'s. Another attribute is sex ratio(eg- 60% female & 40% male).

If age distribution is plotted for population the resulting structure is age pyramid(shown in diagrams). If there are 20 dog & 8 are borned hence birth rate is 8/20= 0.4 puppy per dog.

POPULATION DENSITY (N)- no. Of people per unit area.

Population size and need not only ne studied in no.'s although total no. Is most appropriate method but it is either difficult or meaningless in some cases. (Eg- banyan tree & parthenium hysterophorus. In those cases, the percent cover or biomass is good measure. In infinite population cases relative density works same as absolute density.

The tiger census in our national parks and tiger resources is often based on pug marks & fecal pellets.

Life history variation

Population evolve to maximise their reproductive fitness and achieve their reproductive fitness & achieve their position in darwinian fitness i.e. (higher value) i.e. selection.

Organisms breeding once in life- bamboo, pacific salmon fish

Breed many times- most birds & mammals

Produce large no. Of small sized offsprings- oysters, pelagic fishes

Small no. Of large sized offsprings- birds & mammals

Population growth

Natality & immigration contribute to an increase in population density & mortality & emigration to a decrease.

Natality- no. Of births during a given period that are added to initial density. (NEET 2018)

Mortality- no. Of deaths

Immigration- out to into the habitat under consideration

Emigration- no. Of individual who left the habitat under consideration.

$$N_{t+1} = N_t + [(B + I) - (D + E)]$$ → NEET 2013

Growth models- we can learn from nature how to control population growth.

1) EXPONENTIAL GROWTH- when resource is unlimited then population density become enormous in less time showed by darwin in elephant & cheek

Increase/ decrease in N during unit time period t = dN/dt

$dN/dt = (b - d) \times N$

Let $(b-d) = r$, then

$dN/dt = rN$

$N_t = N_0 e^{rt}$ (Integral form) → AIPMT 2011

where

N_t = Population density after time t

N_0 = Population density at time zero

r = intrinsic rate of natural increase

e = the base of natural logarithms (2.71828)

In 1981 r in india was 0.0205

2) LOGISTIC GROWTH- when the resource in the habitat are finite it limits growth and that population shows initially a lag phase followed by acceleration & deceleration & finally an asymptote when population density reaches the carrying capacity.

It is also called as verhulst-pearl logistic growth in which fittest survives.

Considered more realistic one

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

Where N = Population density at time t

r = Intrinsic rate of natural increase

K = Carrying capacity

NEET 2016

NEET 2017

Population interaction

None of single species can only survive in isolation, it need to interact.

- Predation +-
- Competition --
- Parasitism +- (NEET 2016)
- Commensalism -0 (NEET 2016)
- Mutualism ++

Predation

MERITS OF PREDATION

> transfer to higher levels the energy fixed by plants. Eg- sparrow eating a seed.

> they keep prey population under control otherwise it will rise enormously.

Prickly pear cactus was introduced in australia in 1920 (early) causing havoc by rising population because nopredator is available. Afterward it was controlled by moth.

> maintain species diversity in community.

> controls the inter-specific competition i.e. make it less. Eg- in american pacific coast, all starfish removed and hence 10 species of invertebrates became extinct within a year.

WAYS USED BY PREY TO ESCAPE FROM PREDATION

> insect, frog get caumouflaged to avoid being detected.

> some are poisonous & often been rejected by predators.

> Monarch butterfly is distasteful because of chemical that he aquires during caterpillar stage by feeding on a poisonous weed. Nearly 25% of all insects are phytophagous.

> thorns in acacia & cacti, killing chemicals in plants, poisonous cardiac glycosides in calotropis, variety of chemical substance (nicotine, caffeine, quinine, strychnine, opium,etc.) in plants to defend from predators.

Herbivores/plants face more competition than carnivores.

Competition

Interspecific competition is a potent force in organic evolution but it can also occur b/w organisms species for same resource. Eg- South American lakes, fishes & flamingoes both compete for zooplankton.

Competition can also take place when there is abundant resource. Hence competition is a process in which the fitness of one species (measured in 'r' terms the intrinsic rate of increase) is significantly lower in presence of another species.

Abingdon tortoise in galapagos island became extinct after a decade after goats were introduced, due to great browsing efficiency of goats.

Competition also gets borned due to competitive release i.e. dominant species expands as other competitive species is removed. Eg- in rocky sea coasts of scotland, superior— barnacle balanus, excludes and smaller— barnacle chathamalus.

GAUSE'S COMPETITIVE EXCLUSION PRINCIPLE- competitive species cannot coexist together but it is only possible when resource is limited. It fails in the aspect that they point out that species facing competition might evolve mechanism to promote co-existence rather than exclusion. Eg- resource planning (Mc arthur showerd 5 closely related species of warbler living on same tree were able to avoid competiotion by behavioural changes in foraging activity.

NEET 2016, 19

Parasitism

AIPMT 2011, 12

Many parasites are host specific-in such a way that they both tend to co-evolve i.e. if host develop mechanism to resist parasite need to evolve in such a way to counter it.

SPECIAL ADAPTATIONS IN PARASITES-

1) absence if unnecessary sense organs
2) presence of adhesive / suckers.
3) loss of digestive system
4) high reproductive capacity.

Their life cycle involve 1 or 2 intermediate host or vectors.

Eg- human liver fluke (trematode parasite) depends on snail & a fish. Malaria parasite require mosquito vector.

Most parasites harm host & reduce its population density, they might render the host more vulnerable to predation by making it physically weak. Parasites feeding on ext. surface - ectoparasites. Eg- lice on human, ticks on dogs, copecods on marine fish, cuscuta on plant which derive nutrition from plant due to absence of chlorophyll.

Female mosquito is not a parasite although it needs our blood for reproduction.

Endoparasites have much complex life cycle.

Brood parasitism in cuckoo (koel) & crow i.e. due to evolution of similar looking eggs. Cuckoo lay eggs in crows nest and he incubate them during breeding season (spring to summer)

Commensalism

Examples- (+,0)

> orchid growing as an epiphyte on mango branch.
> barnacles growing on back of whale.
> cattle erget remove insects from grazing cattle.
> clown fish near sea anemone with stinging tentacles being protected.

NEET 2013, 2019

Mutualism

Lichen = algae/cynobacteria + fungi, mycorrhiza = fungi + root of higher plant

B/w plant and pollinator (needs nectar) it should be safe guarded by cheators.

Evolution:- in many species of fig tree pollination is done by only wasp and the tree provides fruit for oviposition of wasp & its seed for nourishing the larvae of wasp.

Orchids show a bewildering diversity of floral patterns many of which have evolved to attract the right pollinator insect (bees & bumble bees) and ensure guaranteed pollination by it. Not orchids offer rewards. The mediterranean orchid ophrys employs 'sexual deceit' to get pollination done by a species of bee. One petal of its flower bears an uncanny resemblance to the female of the bee in size,colour & markings. The male bee is attracted to what it perceives as a female pseudocopulates with the flower and during that it is dusted with pollen. When the same bee pseudocopulates with another flower it transfers pollen to it and thus pollinates flower. Here co-evolution works as a key!

NEET 2017

NCERT Diagrams for reference

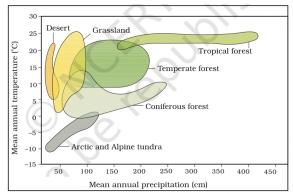


Figure 13.1 Biome distribution with respect to annual temperature and precipitation

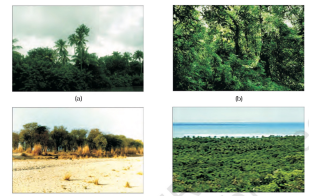


Figure 13.2 Major biomes of India : (a) Tropical rain forest; (b) Deciduous forest; (c) Desert; (d) Sea coast

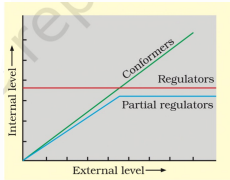


Figure 13.3 Diagrammatic representation of organismic response

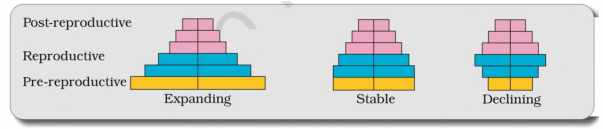
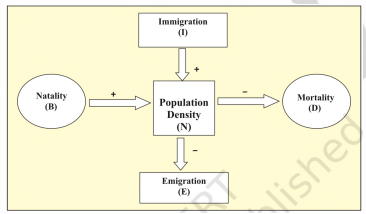


Figure 13.4 Representation of age pyramids for human population



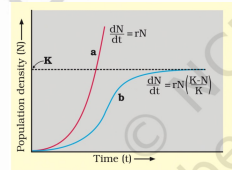


Figure 13.6 Population growth curve
a when responses are not limiting the growth, plot is exponential,
b when responses are limiting the growth, plot is logistic,
K is carrying capacity

Table 13.1 : Population Interactions

Species A	Species B	Name of Interaction
+	+	*Mutualism*
–	–	*Competition*
+	–	*Predation*
+	–	*Parasitism*
+	0	*Commensalism*
–	0	*Amensalism*

Figure 13.7 Mutual relationship between fig tree and wasp: (a) Fig flower is pollinated by wasp; (b) Wasp laying eggs in a fig fruit

Figure 13.8 Showing bee-a pollinator on orchid flower

Ecosystem

Functional unit of nature where organisms react
Many ecologist regard entire biosphere as global ecosystem.
It is of two types - terrestrial (forest,grassland,etc.) and aquatic (estury,wetland).
Crop fields and aquarium can also be considered as man made ecosystem.

Ecosystem- structure & function

NEET 2016

Vertical distribution of different species occupying different levels is called stratification.
Component of ecosystem function as unit when we consider:
1) productivity
2) decomposition
3) energy flow
4) nutrient cycling
Eg- a pond where abiotic components like water, soil & solar input, cycle of temperature, day length regulate rate of function.

The decomposers- fungi , bacteria, flagellates (bottom of pond).
Conversion of inorganic to organic material by plants due to radiant energy and it is consumed by zooplankton which are decomposed and this cycle continues. The loss of energy is in the form of heat.

Productivity

Rate of biomass production in P.P. / time

NEET 2016

Primary production

Amount of biomass/organic matter produced per unit area by plants which is measured in weight (gm-2)/energy(kcal m-2)
GROSS PRIMARY PRODUCTIVITY(GPP)- rate of production of matter by plants. Some GPP is also used in respiration by plants.
NET PRIMARY PRODUCTIVITY (NPP)- GPP - RESPIRATORY LOSSES(R) i.e. available biomass for heterotrophs.

AIPMT 2010, 20, 22

Secondary productivity

Rate of formation of new organic matter by consumers.
Annual net primary productivity of whole biosphere is 170 billion tons (dry weight) of organic matter. Oceans occupy 70% of earth's surface but their productivity is 55 billion tons cause light do not reach bottom.

Decomposition

Earthworm is farmers friend because it decomposes as well as looses soil.
It simply means breakdown of dead remains constitute detritus which is raw material for decomposition which involves some steps.

FRAGMENTATION- Detritivores breakdown detritus in smaller particles.

NEET 2013

LEACHING- Water soluble inorganic nutrients go down in soil horizon and get precipitated as unavailable salts.

CATABOLISM- Fungal enzyme & bacteria convert it into inorganic nutrient. Humification and mineralisation occur during decomposition in soil.

HUMIFICATION- It is to accumulate dark coloured amorphous substance (humus) which is rich in nutrient & highly resistant to microbial action & undergoes decomposition at an extremely slow rate.

MINERALISATION- I.e. degradation of humus by microbe to release inorganic nutrient.
Decomposition requires O2 & its rate is controlled by composition of detritus & climatic factors. Rate is slow when detritus contain lignin & chitin but is fast when it contain N2 & H2O soluble sugars.
Temp. & soil moisture affect action of microbes. Warm & moist environment is favourable for it and anaerobiosis is disastrous for it because formation of organic material takes place.

AIPMT 2006

Energy flow (10% energy law)

AIPMT 2011, 16, 14

Of the incident solar radiation less than 50% of it is photosynthetically active radiation (PAR). Plants capture 2-10% of PAR.
Energy flow follows 1st law of thermodynamics but doesn't follow 2nd. Death of organism is beginning of detritus food chain/ web. The primary consumers will be herbivores and common herbivores in aquatic ecosystem are molluscs.

Carnivores/sec. consumers can be primary (feed on herbivore) or secondary (feed on primary carnivore).
GFC (Grazing food chain)- grass (producer) —> goat (primary consumer) —> man (secondary consumer) —>
The detritus food chain (DFC) Begins with dead organic matter made up of decomposers/saprotrophs. In aquatic ecosystem GFC is major conduit of energy flow but in terrestrial ecosystem in place of GFC, DFC is present.

Omnivores like crow & cockroach make FC as food web (by interconnection). Based on source of nutrition animal gets its trophic level (places in food chain)
Each trophic level has a certain mass of living material at a particular time called as the standing crop which is measured as mass of living organism(biomass) or the no. In a unit area. Measurement of biomass in fry weight is more accurate.

Ecological pyramids

NEET 2019

>Relationship expressed in terms of number, biomass, energy gives out a pyramid.
> no generation is preferred in concept.
> species like sparrow are present on more than 1 trophic level which is a limitation of it.
> generally all pyramids are up right but it is wrong in some cases like in sea ecosystem {inverted}
> energy pyramid can never be inverted as it is lost in form of heat and each bar in the pyramid indicates amount of energy in a given time/annually/unit area.

LIMITATIONS:-
1) species present at more than 1 trophic level
2) a very simple food chain is considered which is not real.
3) saprophytes didn't got place in the pyramid.

Ecological succession

AIIMS 2015

The adaptations/ changes lead finally to a community that is near equlibrium with the environment & that is called a climax community.
The predictable change in species composition of a given area i.e. decline or increase numerous is called ecological succession and the entire sequence of communities are called sere (S).
The individual transitional communities are termed seral stages or seral communities.
Succession is a process that start in an area where no living organism live.
In it the type & no. Of animal & decomposers also change.
Human induced disturbances/interference can result into earlier or progressive stage.

Primary succession

If the area is that where no life existed then it is known as primary succession. Eg- newly cooled lava, bare rock, newly created pond, reservoir. The process is slow & soil is needed and it is also based on climate. It takes many years to form fertile soil.

Secondary succession

If the area is that where life existed before then it is called secondary succession. Eg- farm lands burned or cut forests, flooded lands. It is faster because of soil.

Succession of plants

HYDRARCH SUCCESSION
NEET 2015
> hydric to mesic condition.
>Species invade a bare area are called pioneer species.
>lichen secrete acid on rock to dissolve and forms soil. Bryophytes hold some of soil & replaced by higher plants & forest is made.

XERARCH SUCCESSION
NEET 2016
> xeric to mesic condition.
> explained at back i.e. phytoplankton —> rooted submerged plant —> rooted floating angiosperms—> free floating plants

In secondary succession climax is reached more quickly & depends on many factors like availability of water, condition of soil, etc.
Climax in plant succession is mesic.
See diagram!

Nutrient cycling

NEET 2013 2015

> amt. of nutrient present in soil at a given time is known as standing state. Movement of nutrient elements through various components of ecosystem is called nutrient cycling/biochemical cycles which are 2 types
1) SEDIMENTARY CYCLE- its reservoir is earth's crust (eg- phosphorus sulphur cycle).
2) GASEOUS CYCLE- reservoir is present in atmosphere (N2,C cycle)
Function of reservoir is to meet with the deficit which occurs due to imbalance in the rate of influx & efflux.

Ecosystem- carbon cycle

> C constitutes 49% of dry wt. of organism i.e. next to H2O
> 71% of total carbon is dissolved in oceans.
> atmosphere contain 1% of total carbon.
> oceanic reservoir regulates amt. of CO2 in atmosphere & fossil fuel also represent a reservoir of carbon.
> 4*10^13 kg of carbon is lost to sediments & removed from circulation

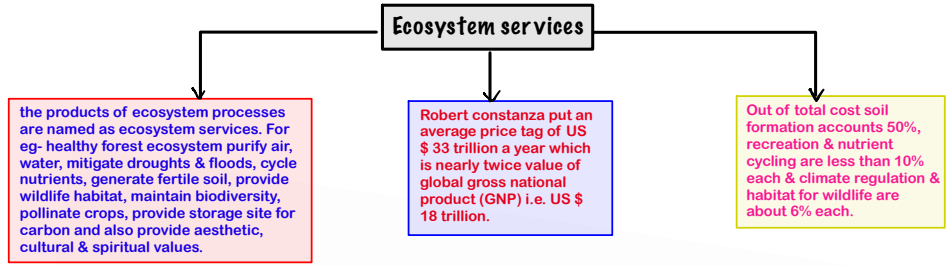
Ecosystem- phosphorus cycle

NEET 2013

> used by many animals to make shells, bones, teeth.
> natural reservoir is rock which contain (P) in form of (PO4^3-)phosphates.
> rocks are weathered —> phosphate dissolve in soil solution —> plants absorb it —
> get eaten by herbivore —> get decomposed by phosphate solubilising bacteria.

DIFFERENCE BETWEEN C & P CYCLE

1) atmospheric inputs of phosphorus thr' rainfall are much smaller than carbon inputs.
2) gaseous exchange of phosphorus b/w organism & environment is negligible.



NCERT Diagrams for reference

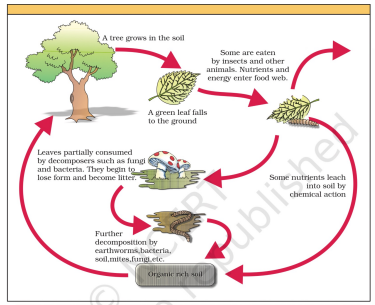


Figure 14.1 Diagrammatic representation of decomposition cycle in a terrestrial ecosystem

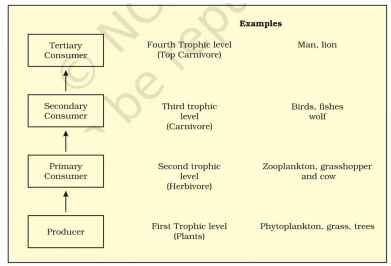


Figure 14.2 Diagrammatic representation of trophic levels in an ecosystem

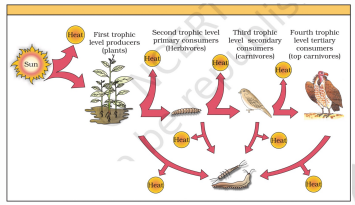


Figure 14.3 Energy flow through different trophic levels

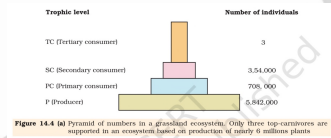


Figure 14.4 (a) Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 millions plants

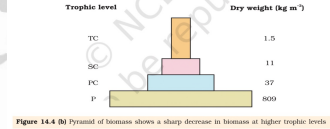


Figure 14.4 (b) Pyramid of biomass shows a sharp decrease in biomass at higher trophic levels

Figure 14.4 (c) Inverted pyramid of biomass-small standing crop of phytoplankton supports large standing crop of zooplankton

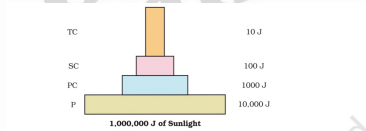


Figure 14.4 (d) An ideal pyramid of energy. Observe that primary producers convert only 1% of the energy in the sunlight available to them into NPP

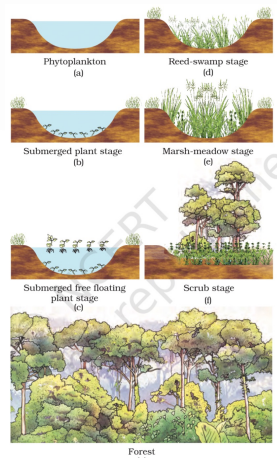


Figure 14.5 Diagrammatic representation of primary succession

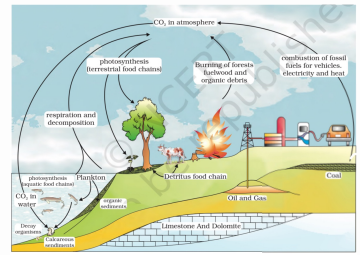


Figure 14.6 Simplified model of carbon cycle in the biosphere

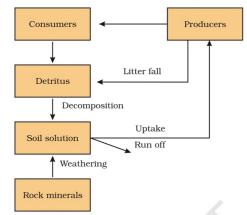


Figure 14.7 A simplified model of phosphorus cycling in a terrestrial ecosystem

Biodiversity & conservation

More than 20,000 species of ants. 3,00,000 species of beetles, 28,000 species of fishes & nearly 20,000 species of orchids are present.

Biodiversity

The term biodiversity was given by edward wilson

Genetic diversity

NEET 2013

Single species may have high diversity genetically.
Eg- rauwolfia vomitoria in terms of potency & conc. Of reserpine, 50,000 different rice strains, 1000 variety of mango.

Species diversity

Eg- western ghat have more amphibians than eastern ghat.

NEET 2020

Ecological diversity

Eg- on ecosystem level india have greater ecosystem diversity than scandinavian country like norway.

How many species are there on earth & how many species in india?

AIPMT 2011

* according to international union for conservation of nature & natural resources (IUCN 2004) [illegible] than 1.5 M species of animal & plant still described.
* more species are need to be describe in tropical than temperate zone of insects.
* extreme estimates- 20-50 million total species in world
* according to robert may - 7 million global species.
* total species (100%) = 70% animal + not more than 22% plants (with fungi) NEET2013
* total animal species (100%) = 70% insects i.e. out of every 10 animal 7 are insect.
* no. Of fungi species > fishes + amphibia + reptile + mammal
* species of prokaryotes are not known because they are not easily culturable.
* india holds 2.4% of worlds land area & shares 3.1% of species diversity i.e. why india holds place in 12 mega diversity countries of world.
* we have 45,000 plant species & 90,000 animal species i.e. there is hope of 1 lakh plant species, 3 lakh animal species in india.
* this is a little impossible task as species extinct before their discovery.

NEET2020

Patterns of biodiversity

Latitudinal gradient

2020

Most well known pattern of biodiversity.
> tropics (latitudinal range of 23.5°N to 23.5°S) harbour more species than temperate or polar areas.
> columbia (near equator) have 1400 species of birds & New York (at 41°N) have 105 species & green land (71°N) only 56 species.
> india (being tropical) have 1200 species of birds.
> tropical region like equator have 10x the diversity in temperate region like USA midwest.
> amazon rain forest species = 40,000 plant sp. + 3000 fish + 1300 birds + 427 mammals + 427 amphibians + 378 reptiles + 1,25,000 invertebrates + 2 million insect sp. have to be found & discovered yet.

REASON FOR HIGH DIVERSITY IN TROPICAL REGION:

1) tropical region have been undisturbed since long.

2) tropical environment is less seasonal & more constant/predictable which supports niche.

3) more solar energy is available on tropical area.

Species-area relationship

NEET2017

Alexander von humboldt (german naturalist) told that species richness increase on increasing the range of area but to a certain limit hence the graph is rectangular hyperbola.
On a logarithmic scale, the relationship is a straight line described by equation.
LogS = logC + ZlogA where S = species richness, C= y intercept + z = slope of line (regression coefficient), A= area
Z lies b/w 0.1 & 0.2 for any area(region) or taxonomic group but if ares is very large the graph is more steeper i.e. Z lies b/w 0.6 to 1.2 for eg- frugivorous birds/mammals in tropical forest(continent) the slope is found to be 1.15.

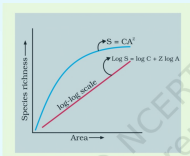


Figure 15.2 Showing species area relationship. Note that on log scale the relationship becomes linear

The importance of species diversity to the ecosystem

It was belie that community with more species is more stable i.e. not show too much variation in productivity resistant/resilient to disturbance & should resist invasion by alien species.

David tilman proved this in his plot experiment and also showed that increased diversity leads to higher productivity. Plots with higher species hence less year to year variation in biomass.

Paul ehrlich exampled that loss of key species from ecosystem can affect severely to ecosystem by his aeroplane, rivets example.

Loss of biodiversity

NEET 2016, 14

Colonisation in tropical pacific islands led to extinction of 2000 species of birds (native).
IUCN Red list (2004) showed the extinction of 784 species (338 vertebrates + 359 invertebrates + 87 plants) in last 500 years.
Eg- dodo (mauritius), quagga (africa), thylacine (australia), steller's sea cow (russia), [Bali,Javan,caspian] —> subspecies of tiger.
In last 20 years 27 species got extinct & amphibians are more reliable to extinct.
15,50l species worldwide are facing threat of extinction.
12% of total birds, 23% mammal, 32% amphibians, 31% gymnosperms face the threat of extinction.
Many years ago 5 mass extinction occurred and 6th episode is going on with 100 to 1000 x faster rate and by this 1/2 of species will extinct in 100 years.

Loss in biodiversity may lead to-

1) decline in plant production.
2) lowered resistance to environmental perturbations.
3) increased variability in plant production, water use, pest & disease cycles.

Causes of biodiversity losses (The evil quatret)

HABITAT LOSS & FRAGMENTATION-
Once tropical forests covered 14% of area & now 6% is also not left.
Amazon forest —> lungs of planet.
Amazon is cleared for growing soyabean, & grazing yards.
Pollution also plays role in it.

OVEREXPLOITATION-
(When need change to greed) species like stellers's sea cow, passenger pigeon extinct in 500 years due to over exploitation & now marine fishes became endangered due to their over exploitation for commercial use.

ALIEN SPECIES INVASION-
NEET 16, 19
Causes extinction of indeginous species.
Introduction of nile perch in victoria lake (east africa) led to 200 species extinctionof cichlid fish.
Weeds like parthenium, lantana, eicchornia also acts as alien species. Recently african catfish clarias gariepinus for agricultural purposes poses threat to indeginous catfishes in our rivers.

COEXTINCTION-
Species dependent on extinct species also get extinct.
Eg- coevolved plant pollinator mutualism.

BIODIVERSITY CONSERVATION

Why should we conserve biodiversity?

NARROWLY UTILITARIAN ARGUMENTS-
Are obvious & direct economic benefits.
> directly food (cereal,etc) firewood, fibre, construction material industrial product (tannin,lubricant, dye,resin, perfume) medicines.
> 25% of drugs come from plant & 25,000 species of plants have medicinal importance. Resources put in bio prospecting (exploring molecular, genetic species & products of economic importance) nation can get enormous benefits.

BROADLY UTILITARIAN ARGUMENTS-
Biodiversity plays important role in many ecosystem services that nature provides.
> amazon produces 20% of total O2 which is priceless.
> pollinators (without them there is no fruit & seed)
> joy of visiting places (mountains) & pleasures, etc.

ETHICAL ARGUMENTS-
Its our moral duty to protect every creature whether it is economically beneficial to us or not.

NEET 19,21

How do we conserve biodiversity?

To conserve normally like tigers we use in situ (on site) conservation & to conserve endangered species we use ex situ (off site) conservation.

In situ conservation

For maximum protection certain (biodiversity hotspots) regions were chosen with high species & high degree of endemism (species confined to an area and not found anywhere else).
Initially 25 hotspots are identified but 9 are more added to the list =34.
Hotspot are the regions of accelerated habitat loss.
In india there are - western ghats, sri lanka, indoburma & himalayas hotspots.
All hotspots cover less than 2% of earth's land & their protection can decrease mass extinction by 30%.
India have 14 biosphere reserves, 90 national parks & 448 wildlife sanctuaries.
In india, in many cultures tracts of forests were set aside and all the trees & wild life within were venerated & given protection.
Such sacred grooves are found in khasi & jaintia hills in meghalaya, aravalli hills of rajasthan, western ghat regions of karnataka & maharashtra & the sarguja, chanda & bastar areas of madhya pradesh.
In meghalaya the sacred grooves are the last refugees for a large no. Of rare & threatened plants.

Ex situ conservation

Animals kept in special care for eg- zoological parks, botanical garden, wildlife safari parks.
New gametes of threatened species can be preserved in fertile conditions for long period using cryopreservation techniques, eggs can be fertilised in vitro, plants cultured in tissue culture, seeds can be stored in seed banks, commercially important.
Earth summit held at rio de janeiro in 1992 called nations to take appropriate measures for biodiversity conservation & sustainable utilisation.
World summit held in johannesburg (south africa) in 2002 on sustainable development where 190 countries pledged to decrease loss of biodiversity by 2010.

NEET 2018, 16, 19 AIPMT 2009

Environmental issues

POLLUTION- undesirable change in physical, chemical or biological characteristics of air, land, water or soil & agents that bring that change are known as pollutants.
Indian govt. passed environment protection act in 1986.

Air pollution & control

Air pollutants cause reduction of growth & yield of crops & cause premature death of plants. Harmful effect depends upon conc. Of pollutant, duration of exposure & organism.

Smoke stacks of thermal power plant, smelters & other industries release particulate & gaseous air pollutants with N2 & O2 which are to be filtered.

ELECTROSTATIC PRECIPITATOR- Remove 99% of particulate matter from thermal power plant.
It have electrode wires maintained at many 1000V. They produce corona that release electron. Electron stick to dust particles giving them -ve charge. Collecting aplates are grounded & attract the charged dust particles.
Velocity of air b/w plates should be low so that particles fall on plate.

SCRUBBER- Remove gas like sulphur dioxide (SO2)
AIPMT 2011

According to central pollution control board (CPCB), Particulate size 2.5 micrometers or less in diameter (PM 2.5) Causes breathing/lung problems/inflammation in humans.

Use of lead free petrol & catalytic converter is good against pollution.
In catalytic converter, platinum, palladium, rhodium is used as catalyst which convert unburnt hydrocarbon into $CO_2 + H_2O$ & CO , NO(nitric oxide) into CO_2 & N_2 Respectively. But catalyst loose their activity on use of lead containing petrol.

Air (prevention & control of pollution) act came into force in 1981 but was amended in 1987. Noise causes psychological disorder i.e. why it is also an air pollutant. 150 dB sound (jet plane/ rocket) may impaire hearing loss but extremely low noise sound can destroy hearing ability of one.

Noise causes sleeplessness, increased heartbeat, stress altered breathing. Low horn in school & hospital premises, low sound of crackers, loud speaker time management can control noise pollution.

NEET 2001, 2010 2013

Water pollution & control

Water (prevention & control of pollution) act, 1974 was passed to safeguard water.

Domestic sewage & industrial effluents

From sewage water solids are easy to remove but how to remove dissolved salts such as nitrates, phosphates, toxic metal ions, organic comp. only 0.1% of impurity make water unfit for consumption.

AIPMT 2012 NEET 2022

We can estimate amount of biodegradable organic matter in sewage water by measuring biochemical oxygen demand (BOD). The microorganism involved in biodegradation consume O_2 dissolve and hence O_2 dissolved get decrease which causes mortality of fish, etc.

Because of nutrients in H_2O planktonic (freely floating) algae called algal blooms settle on it which causes deterioration of water quality & fish morality. Some are extremely toxic to humans.

AIPMT 2011 NEET 2021

Water hyacinth/ eichhornia crassipes, the world's most problematic aquatic weed, which looks beautiful but blocks the water ways. It is also called terror of bengal. They grow abundantly in eutropic water bodies.

Sewage from our home & hospital contain harmful microbes which causes diseases. Industrial waste water contain heavy metals (density > 5g/cm3 eg- Hg, Cd, Cu, Pb), organic compounds which can undergo biological magnification. Because the toxic material can't be metabolised or excreted & is well known for Hg & DDT.

High conc. Of DDT disturb calcium metabolism in birds, thus thinning of shell & their premature breaking eventually causing decline in bird population.

AIPMT 2012 NEET 2016

EUTROPHICATION- natural aging of a lake by nutrient enrichment of water.
Water is cold in young lake & introduction of nutrient take place. Lake's fertility increase & organic remain deposit at bottom of lake. Lake gets shallower & water become warm & large floating plants (bog). This process leads to formation of land & naturally it might take 1000 yrs the process depends on climate, size of lake.

AIPMT 2015

Man's activity like effluents from industry causes accelerated/cultural eutrophication. The prime contaminants are nitrates, phosphates (plants nutrients) which overstimulated algae growth causing unsighty scum & unpleasant odour & less dissolved O_2. Thermal wastewater from thermal water plants eliminate. Some species of may enhance growth of plants & fish in extremely cold areas but only after causing damage to the indegenous flora & fauna.

Solid wastes

Municipal solid waste (from home, office ,store, school,hospital) which comprise paper, food are compacted & filled in sanitary landfills in place of open dumps but it also affects the underground H2O system hence we should, sort the garbage into biodegradable, recyclable & non-biodegradable ones & use eco-friendly packages. Hospital waste need to be disposed by use of incinerators.
Solution to electronic waste is either exposed to landfills or recycling (in developed countries) recycling of electronic waste in developing countries should be in environment friendly environment because there are toxic material.

Agro-chemicals & their effects

AIPMT 2007

Pesticides, fungicides, herbicides (inorganic fertilisers) are excessively used after introduction to green revolution. It can cause biomagnification in terrestrial ecosystem & eutrophication in aquatic ecosystem. It can also affect the non target organisms & soil nature.

Radioactive wastes

Nuclear energy is used as nonpolluting source of electricity. But problems associated are- accidental leakage (eg- three mile island & chernobyl incident)
And safe disposal of radioactive waste because it causes mutation at very high rate and hence also causes cancer. Its disposal needs pre treatment, done in shielded containers buried within rocks about 500m deep below earth's surface. But it is opposed by public.

Polyblend – 2019 NEET
chipko movement – AIPMT 2004
JFN – AIPMT 2004

Green house effect & global warming

AIPMT 2011
NEET 2019, 2013

It is responsible for heating of earth's surface & if it would not there then earth's temperature would be -18°C than the present avg. of 15°C.
1) sunlight is reached to the layer of clouds of gases (CO_2 & CH_4).
2) 1/4 of sunlight is reflected back & 1/4 is absorbed by the gases & 1/2 is sent to the surface.
3) some of it is absorbed by earth's surface & emits infrared radiation but it is absorbed by CO_2 & CH_4.
4) the molecules of gases radiate heat which comes to earth and again the cycle continues.
This causes heat i.e. global warming & during past century earth's temperature has increased by 0.6°C & further increase may lead to abnormal environmental changes (eg- Elnino effect) & because of it the glaciers also started melting and because of which sea level may rise & tropical areas/ coastal areas may get submerged in the sea.
For putting control on it we should make down the use of fossil fuel, improving efficiency of energy usage, afforestation, check of population.

Ozone depletion in the stratosphere

NEET 2019, 18, 20

Good ozone is near earth's surface (troposphere) & bad ozone is in upper part of stratosphere.
UV radiation breaks molecular bonds within DNA.
Thickness of ozone from ground to top is measured in Dobson units (DU).
The degradation of ozone take place due to CFC'S which release Cl in presence of UV & that Cl tends to break O_3 into O_2 & O. Hence it depletes the ozone layer & it is majorly taking place at Antarctic region in form of ozone hole (very thin ozone).
Wavelength shorter than UV-B is absorbed by earth but UV-B mutates DNA. It causes aging of skin & skin cancer, inflammation of cornea called snow blindness, cataract.
An international treaty called montreal protocol signed at montreal (canada) in 1987 to control the emission of ozone depleting substance.

Degradation by improper resource utilisation

1) SOIL EROSION & DESERTIFICATION

Because of over cultivation, overgrazing , deforestation, poor irrigation resulting in arid patches of land. Barren land extends desert is formed mainly caused urbanisation.

AIPMT 2005

2) WATERLOGGING & SOIL SALINITY-

Over irrigation without proper drainage causes waterlogging. Water starts depositing as a thin crust & starts collecting roots. This causes damage to agriculture.

AIPMT 2015

NEET 2016

Deforestation

40% forests have been lost in tropics, compared to only 1% in the temperate region.
In the beginning of 20th century 30% of land of india was covered with forest but by end it was 21.54%
National forest policy (1988) of india has recommended 33% forest cover for plains & 61% for hills.
Reforestation can only overcome deforestation.

Cause of deforestation

✓Conversion of forest to agricultural land.
> for timber, firewood cattle ranching.
> slash & burn agriculture/ jhum cultivation in north-eastern state.

Consequences of Deforestation

> release of CO_2 to atmosphere.
> loss of biodiversity due to habitat destruction.
> disturbs hydrologic cycle, causes soil erosion & may lead to desertification.

NCERT Diagrams for reference

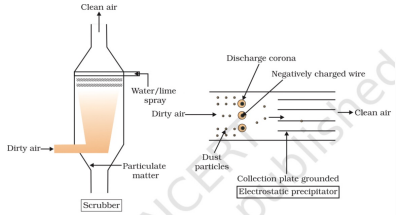


Figure 16.1 Electrostatic precipitator

Table 16.1: Table Showing the Mass Emission Standards in India

Type of Vehicles	Norms	Cities of Implementation
4 Wheelers	*Bharat Stage IV*	*Throughout the country since April 2017*
3 Wheelers	*Bharat Stage IV*	*Throughout the country since 1st April 2017*
2 Wheelers	*Bharat Stage IV*	*Throughout the country since April 2017*

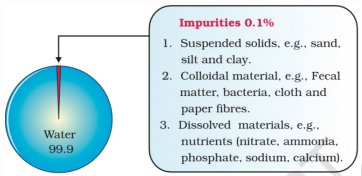


Figure 16.2 Composition of waste water

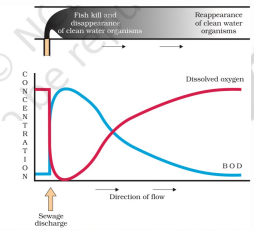


Figure 16.3 Effect of sewage discharge on some important characteristics of a river

Figure 16.4 Pictorial view of an algal bloom

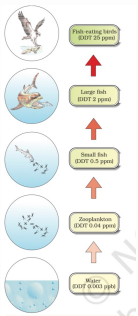


Figure 16.5 Biomagnification of DDT in an aquatic food chain

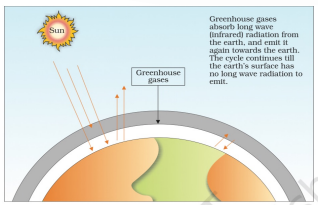


Figure 16.6 Sunlight energy at the outermost atmosphere

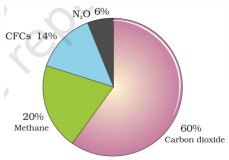


Figure 16.7 Relative contribution of various greenhouse gases to total global warming

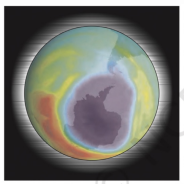


Figure 16.8 Ozone hole is the area above Antarctica, shown in purple colour, where the ozone layer is the thinnest. Ozone thickness is given in Dobson unit (see carefully the scale shown in colour violet to red). The ozone hole over Antarctica develops each year between late August and early October. *Courtesy: NASA*